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ORTHOPAEDIC SURGERY IN THE LIGHT OF ITS EVOLUTION *

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This is not to be a history of Orthopaedic Surgery. Rather is it to be the review of an evolutionary story, similar to that of Medicine and of Surgery itself and as free from personalities as I can make it. It is my aim to do this, since it is my principal objective to attempt to descry, back of the account which I shall present, what there is of ideology and of idealism in what we are doing, as measured by the place which we would assume in the general medical scene. I have chosen this theme for the reason that I have so often asked myself: What is it that we are doing, day after day, in one of the most exacting and laborious branches of our profession? Are we simply performing certain tasks which colleagues and others have permitted or requested us to do, content to have done them as well as we may and satisfied to have the morrow bring its burden of the same types? Or, is it possible that through all of our striving there runs a definite pattern? Have we a philosophy, as it were, with a purpose of praiseworthy character,—a purpose which, though it change with the times, is no less dignified, as it is no more faltering, than that of any other department of medical science and art? For it does respond, in common with the best of them, to the dictum of Bacon in his "*Novum Organum*": "Now the true and lawful goal of the sciences is none other than this: that human life be endowed with new discoveries and powers."

The beginnings of the methods and procedures which are now comprehended in the equipment of the orthopaedic surgeon go back to the most ancient times. Pieces of apparatus designed to straighten crooked spines and feet are pictured in the most archaic treatises. These were the inventions and implements of physicians, however; surgeons, as such, had no existence save as there happened to be some men who were possessed of unusual inventiveness or manipulative skill which commended them and which became publicized after the manner of the time. Out of

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the long story of Medicine, certain names stand forth in resplendence. To some of them we are accustomed to look as the pioneers of what we, today, call Orthopaedic Surgery. In like manner, we might as well hark back to the mythical Vulcan and to Tubal-cain, the fashioners of metal; to the inventor of the lever and the screw we might turn as great contributors. But the master of modern constructive methods was he who first learned to ascertain the stresses which must be borne by materials and to compute the resisting capacity of the various ones. Only thus, out of the great conglomerate of discoveries and inventions, could come the later contrivances of men and those complicated devices which have become so integral a part of our modern civilization.

If we have decided to put away from us the temptation to sift through historical chronicles in order to segregate each single human accomplishment which may, by any stretch of the imagination, be said to belong to the resources of Orthopaedic Surgery, we shall nevertheless have to find a starting point. The derivation of the word "Orthopaedia" has been commented upon so often that I shall not willingly add more. However, like Banquo's ghost, it will not be downed. There is, in fact, a ghost which requires to be laid and it is that of Andry, himself, in whose book the name first appeared. I have had before me Andry's book, published in 1741, as well as two small volumes of even greater interest. They constitute an English translation with additional comment and are of the date 1743. The essential fact in both of these is that the treatise deals with the cosmetic aspects of the child,—it has to do with the appearance of the body almost exclusively, and it is concerned with the hair, face, eyebrows, nose, eyelids and lashes, pockmarks, pimples, gums, and even artificial teeth. It is a book for the layman and makes not the slightest pretense of being a scientific contribution, even in the spirit of its own time. In short, Andry has bequeathed to us naught but a name,—a name, however, whose present usage no longer resembles that of the original even remotely and some of whose other implications make us inclined to writhe. Would that I might give to you a better and say to this name: "*Requiescat!*" But I shall not try to do so.

SPECIALISM

The conditions leading up to the development of specialism, as we know it today in Surgery and in Medicine, may be observed in their gradual appearance as far back as the records of our profession can lead us. I do not mean this in the highly exaggerated sense of ancient Egypt, where an individual learned nothing beyond the concerns of the one organ upon which his interest was centered. There is no purpose in being occupied with detail, at the moment, but it may serve us usefully to glance at the causes whose slow accumulation and effects have produced what is, perhaps, the one thing which distinguishes Medicine of today from that of the recent past. It seems fairly certain that the first step toward specialism did not lie in the increase of knowledge, but, rather, in

the consciousness of some persons that they possessed certain talent or skill to do particular things, by means of their personality or with their hands, which were not at the command of others about them. The demonstration of such specialized ability was productive of enhanced reputation among the people, but, at the same time, it did great violence to the canons of a profession which was still in its swaddling clothes. Medicine depended, for the most part and in olden times, upon empiricisms and rationalizations which had no real physical basis and which were destined to disappear with increase of knowledge and that arrangement of observed phenomena which we call "science". Hence we find in the Hippocratic oath the prohibition against cutting for stone; for many centuries after the physician of Cos, we find relegated to the barbers all of the cutting procedures as well as the other things done for patients with the hands. These things were assigned to the barbers as being beneath the dignity of the truly learned. The differentiation of the "*Chirurgus*" from the "*Medicus*" out of the number of persons offering help to those in impaired health seems to have occurred long before the term "*Doctor*" was used, since this designation was an ascription of unusual knowledge in its connotation of the ability to teach and in its significance of a career of scholarship and of philosophical study. I have little doubt that primarily there was associated with the idea and claim of special skill the conception of a restriction of knowledge and of activity. The comparison of such a narrow sphere with that of one concerning himself with the whole of human ratiocination would not have been considered flattering. We have only to remember that the scholar occupied himself with everything which man found in relationship to the world about him and, scarcely less so, in respect to a world to come. Slow, indeed, was the process of separating the chaff from the wheat and even painfully gradual, at times, the incorporation into our assets of many things which had come from outside the precincts of learning as they were formerly circumscribed. The attempt to establish recognition for any of the special branches of practical medicine and surgery has nearly always met with lay approval and collegial antagonism. I have encountered an amusing example dating prior to 1825. John Abernethy was the immediate successor to John Hunter, the great Professor of Surgery, in London. Though gruff in manner and of testy disposition, he was highly esteemed as a surgeon and a teacher and greatly admired for his fine character. Upon being requested to accept appointment as Honorary President to the London Eye and Ear Infirmary, he declined and used the following words: "I can see no good that can arise from this to the public; it may be of use to the surgeons, but I candidly tell you I consider it quackery; I will never lend my name to sanction it; every surgeon should be acquainted with the diseases of the organs of sight and hearing; and to detach them from regular surgery would be not less injurious to the science than oppressive to the public." It would be pointless to attempt an analysis of the motives underlying such an attitude, or to ascribe to them

an unworthy character. Specialism, both within Medicine and outside of it, has faults and shortcomings, but it has justified itself by what it has accomplished.

I feel as if I had the right to say at this point that Orthopaedic Surgery was one of the first specialties to be practised as such, to the exclusion of other branches of Medicine and Surgery, except as they were necessarily involved. In its earlier American interpretation, fractures and other acute conditions were not dealt with. It is very significant to me that this is still true of most of the European texts on Orthopaedic Surgery. This is particularly the case with those of German authorship,—a matter of especial importance, since, after its development in America, Orthopaedic Surgery found its most luxuriant flowering in Austria and in Germany. It would appear significant to consider the essential basis upon which this early development rested. Even though nowhere stated in such terms in the literature of the period, it seems fair to say that until approximately 1889 *Orthopaedic Surgery consisted of the application of mechanical principles and methods to the correction and cure of the deformities and diseases of the motor apparatus of the body;* it was concerned chiefly, therefore, with the trunk and the extremities. Operative procedures, involving the use of the knife, were largely restricted to very simple ones, such as tenotomy, myotomy, fasciotomy, and the incision of abscesses. I have already said that fractures in their acute phases and acute pyogenic osteomyelitis were not considered as belonging in this field. Corollary to this is the fact that the contributions of original character which came from the group of orthopaedic surgeons during this period were concerned chiefly with mechanical appliances and with manipulative procedures, done perhaps under general anaesthesia, but involving cutting methods of the simplest nature only. It was not long before orthopaedic surgeons were looked upon by general surgeons as an inferior class and were spoken of with contempt, often undisguised. Witness the words spoken by Dr. E. H. Bradford in his address as the third President of the American Orthopaedic Association, in 1889: "But though great progress was made in Orthopaedic Surgery, it is not to be overlooked that it fell from the high estate it held in general surgical interest fifty years ago, until it became an almost despised and rejected branch. The orthopaedic surgeon was regarded as a man of mere straps and buckles, or the custodian of that surgical chamber of horrors, the orthopaedic institute. The reason of this decline of interest is not far to seek, if we recall the fact that fifty years ago the attention of the surgical world was turned to the remarkable feats of the great surgeons who taught us precision, skill, and boldness in the triumphs of the amphitheater, and that the ambition of all men of energy prompted them to emulate those monarchs of the operating table."

It seems especially worthy of note that even after Orthopaedic Surgery had begun to take a place as a specialty, the innovations which were introduced in great profusion for a number of years by its early apostles

belonged in the field of mechanical contrivances. Lengthy discussions ensued as to the comparative advantages of more or less radical operative methods, as contrasted with mechanical, conservative, or the so called "bloodless" modes of treatment for the same abnormal conditions. In the meantime, the steady advances in surgical pathology and bacteriology were receiving rather scant notice from a group whose attention was fixed upon the therapeutic use of mechanical appliances, the study of the disease processes themselves being permitted to remain in the background. Thus can be explained the controversy between the "American", the "English", and the "Austrian" schools concerning the relative advantage of treating chronic disease of the joints of the lower extremities by traction, by stilting, or by splinting, and by various combinations of them. Meanwhile, the solution lay in the study of the disease process itself,—in the distinction between conditions which were truly tuberculous and others which, however much they appeared to be so clinically, came to be known as non-tuberculous. Furthermore, scientific study of the processes of repair was necessary in order to determine how these diseases could be cured. While all of this therapeutic discussion was going on, significant advances in knowledge concerning the true nature of the diseases of the bones, the joints, and their controlling structures were being made; above all, the profession was learning what was really meant by the word "cure" in tuberculosis and how and when it could take place. Was a patient with spinal disease to be regarded as cured simply because, under the protection of a steel support, he had shown no symptoms for a number of years? The definite answer had to come from the laboratory. Even at the risk of courting a reply which may be somewhat unpalatable, let us inquire into the sources of the knowledge which was destined to constitute the basis of much of the progress which came into being. We encounter the names of Brodie, Paget, Ollier, Volkmann, MacEwen, Mikulicz, Lannelongue, König, and Lexer, not to mention many others. The contributions of these men appear to be especially emphasized inasmuch as they consisted of additions to our knowledge of the nature of morbid processes and their behavior under varying circumstances involving or not involving the modifying influence of therapeutic methods. But, be it observed, these are the names of general surgeons working in the academic atmosphere of investigation. The questions may well arise: Were these men better fitted to make these important and basic contributions in the realm of the motor apparatus because they also studied the viscera? Was any one of them better fitted to operate upon the knee joint because he was even more concerned with the surgery of the large bowel? Could it even be said that continued participation in the surgery of the motor apparatus was vital to the maintenance of their general surgical standards? Not at all so, it would appear. It would seem more likely that their contributions could be attributed to the fact that all of their activities were built upon a broad and truly scientific foundation and, ancillary to this, there was necessarily involved the spirit of in-

quiry and the habit of constant search into the nature of underlying principles.

THE COURSE OF EVOLUTION IN ORTHOPAEDIC SURGERY

Up to the time of the development of bacteriology and the consequent antiseptic or Listerian era in surgery, Orthopaedic Surgery was merely a part of the activities of every general surgeon. The contributions to it were partly his and partly, one might justly say, they came from more or less capable artisans who had no academic training whatever. Some of these men provided the surgeon with his operative and other instrumental equipment. Others, like Heine and Hessing in Germany, applied themselves to devising mechanical appliances for the treatment of deformities. In the case of the two just mentioned they did not hesitate to undertake the actual treatment of patients, not infrequently with success as judged by the standards of the time. Often patients were referred to them by accredited members of our profession, who left to them virtually the chief, if not the whole, task of directing and conducting the treatment. That in so doing these surgeons acknowledged their own ineptitude is quite beside the point. The fact is that it was done. Unhappily, we may witness something equally culpable in our own time when patients are sent by physicians to osteopaths and chiropractors, on the unsound reasoning that they have an especial training in physiotherapy,—a statement which would not be so bad were it not wholly untrue. But these were the days when men might with justice speak of "Orthopaedics" and of men like Heine and Hessing as "orthopaedists", for this is what they were; indeed, for years afterward there were many others like them, even though they were dignified with academic degrees.

The fact is that there was no body of information or technique which called for concentration of effort in the minds and hands of a distinct group, in so far as the field of the bones and the joints was concerned, except as the talents and predilections of certain men directed them toward it. When Venel organized the first orthopaedic institute at Orbe, Switzerland, in 1780, he became the first truly specialized and professional "orthopaedist"; this he was, *par excellence*, as far as we know. It is possibly also true that in so doing he laid the ground for that isolation from the rest of surgery which later took place, as well as for a contemptuous attitude on the part of general surgeons which may at times not have been without some justification, granting that there is ever an excuse for it. Shunting aside the blameworthy conduct of certain individuals, there should never be a place for such professional snobbery. When Stromeyer, during the first half of the nineteenth century, popularized the operation of tenotomy for club-foot much good was accomplished, but not a little harm was also wrought. By reason of the operation which Stromeyer performed on the English surgeon, W. J. Little, an enthusiastic advocate was made of Little, and this eventuated in the organization of the Royal Orthopaedic Hospital in London. This operation

was the main feature of Stromeyer's treatment, aided as it may have been by retentive apparatus. We know today how imperfect the end results of such a plan of treatment are bound to be in the majority of instances, whether of the congenital or of the acquired form. While the results which he achieved probably constituted an improvement over those previously obtained, years had to elapse before the essential shortcomings of the method were acknowledged,—before it was realized that very often, yes, most often, the premature performance of tenotomy is unfortunate in its definitive effect, and that *per se* it must usually be regarded merely as a step in the treatment, however useful it may be if done at the right time and properly combined with whatever else is needful. It must surprise those who know these things, in reading the literature of Stromeyer's time, to receive the impression that his patients were cured by the operation. We look in vain for statements of recurring deformity and disability, fully aware as we are that they must have taken place, time and again. It is refreshing to learn that Little eventually made acknowledgment of the shortcomings of tenotomy as a procedure to be relied upon exclusively and if used without discrimination. In Stromeyer, then, we have another example of one who made a useful contribution, but did not do overmuch toward shaping the fundamentals of what was destined to become a field of useful labor for a large group of specialized workers. Soon after the beginning of the Listerian era in surgery came the period of so called "primary resections" for tuberculosis of peripheral joints. Incidental to the recognition of the identity existing between "white swellings" of the knee and ankle and pulmonary tuberculosis, there ensued a veritable "*furor operandi*". Much time was needed to show the futility of these procedures as they were then practised and in view of the after-treatment then in vogue. The frequent incidence of operative infection brought with it the necessity for many subsequent amputations. Mutilation of the epiphyseal growth centers had the lamentable effect of later shortening of such degree that amputation was often found preferable, notwithstanding the unhappy alternative of the inferior prostheses available at that time. Even when such catastrophes were evaded, many of those in whom primary healing was obtained were visited with recurrence *in loco* or at a distance, due to failure of the surgeon to realize that he was dealing not with tuberculous joints but with tuberculous individuals. However obvious such episodes appear to us now and however plain their cause, a long and dreary road had to be travelled by patients and surgeons alike before the nature of the mirage became evident. Witness now that phenomenon in our professional record which we have still to observe on occasion, albeit not characteristic of us but incidental to the imperfection of human reasoning and the enthusiasm of the innovator,—the pendulum having swung too far to the left must move equally far to the right before it assumes a central position. How true this is, not only of individuals or of groups, but even of nations in their corporate affairs! The voice of protest is not heard in the

tumult—or being heard it is drowned in a flood of imprecation and the charge of reaction or of inertia. Thus are we so often prone to lose the lessons which the past may bring us, would we but look for them with the enlightened mind of the present. In this situation, the revulsive attitude of mind, representing the swing to the extreme right and following upon the disappointing outcome of the radical operative policy, became manifest in the United States. Implicit in the genius of this country there appears to be an urge toward the purely mechanical and the inventiveness coupled with it. It is not strange that this flair for mechanical improvisation now invaded the field of surgery also. Long before the essential nature of tuberculosis of bones and joints became clear through the results of pathological and bacteriological research, these lesions had been spoken of as inflammatory, irritative, and destructive. Two opposing schools of thought arose with regard to treatment. If the one group projected their theory that complete physical rest of the body was called for and fortified it by demonstrating the rapid improvement of patients thus treated, both in respect of their local and general condition, the opposition was able to show that the lack of fresh air and sunshine vitiated these results in the end. "Hectic fever", the development of abscesses, and an eventual increase of mortality were pointed to as contra-indicating the institutional method. It is quite amazing how much time had to elapse before it was realized that these views were not truly in opposition, but that they could be reconciled, as they are in fact today. In the meantime, discussion was active in the attempt to explain what was accomplished by rest in recumbency, to what degree complete immobility of the affected joint was needful and desirable, to what extent recovery with loss of motion was dependent upon enforced fixation, and in what measure recovery could take place in defiance thereof. "Natural cure" of certain joint affections, usually with complete loss of motion, was pointed to as indicating the course which our therapeutics should imitate. That entirely differing diseases were being dealt with, at least very often, was in no one's mind. American engineering proclivities soon envisaged a mechanical solution and posed three possibilities for the control of peripheral joints and the spine, as they might be employed singly or in combination. The principle involved was not of American origin in any case; the methods employed were. You may not forgive me for recounting them today; they have almost passed into the limbo of things forgotten. The elements of joint control comprised:

1. Fixation—the restraint of all articular motion to the maximum degree possible.
2. Distraction—the pulling and holding apart of joint surfaces in order to prevent attrition.
3. Stilting—the removal of superincumbent weight to eliminate the percussive effect of walking.

When I say that these things have been almost forgotten, I mean only as they were considered the central objective of treatment. As incidental

and temporary features of treatment, they are all still in use. However, it seems rather unimportant that in the discussions which took place, largely as the result of mechanical contributions from American sources, it was assumed that the axiom of the so called "American School" in the treatment of chronic disease of joints of the lower extremity lay in the dictum that to the extent that motion could take place without friction it was permissible,—that is to say, not harmful. Equally unessential does it now appear whether we take sides with those who endorse the plaster-of-Paris jacket of Sayre in providing fixation and correction of the spine, or with those who favor the steel brace of Taylor in furnishing anteroposterior leverage capable of adjustment as occasion requires. We may admire the simple appliance of Judson for infantile club-foot, or the more complicated machine of Bradford for the reduction of congenital misplacement of the hip. In similar category we may view the many ingenious forms of wrenches with which to apply force externally in correcting deformities. Many of them have been laid aside to the degree of being considered obsolete. Others are still in use. From all of them we have learned something. Common to all of them, however, is the fact that none of them is employed with the constancy and adherence to underlying mechanical action which was originally in the mind of the inventor,—certainly not with the faith in their utility which was his and was by him transmitted to his disciples. It seems fair to say that at this period the attention of the orthopaedic group was fixed much more upon the methods of cure than upon the study of the nature of the diseases which they sought to influence. Turning for the moment from this incomplete glimpse of the mechanical contributions made in this country at an inchoate period of the modern surgical era, let us have a glance at the literary product. It is best found, perhaps, in the transactions of the American Orthopaedic Association, which was organized in 1887. It is important that this be done since it must be realized that, even though many men in many countries and throughout many generations had been doing things which we now consider to belong preeminently within the domain of Orthopaedic Surgery, we have here the opportunity of observing the beginnings of its practice by a specialized group. So far as I know, for the first time in medical history, a number of men, a majority of whom confined their professional efforts to this field, banded themselves together for scientific purposes as orthopaedic surgeons. A quick excursion through the earlier volumes of these Transactions will enable us to note the general character of the papers. No Claude Bernard is to be found among the authors; yet I cannot forbear pausing at this juncture to pay a humble and sincere tribute of homage and admiration. This is not simply by reason of the impressive character of the authors' names. Mingled with the names of Shaffer, Davis, Taylor, Sayre, Bradford, Gibney, Whitman, Ridlon, Sherman, Steele, Gillette, Willard, and Lovett, we shall find many others no longer familiar. The presence of these other names is testimony that they had something to say. What is more

significant to me is that they were encouraged to say it. The protocols of the discussions will be found eloquent of their objective nature but, what is more important, redolent of a fine spirit toward the younger men on the part of those who had already arrived at the stage of leadership.

As we pass in review the list of titles of papers published in the early volumes of these Transactions, we find a predominance of those dealing with clinical descriptions of deformities and the diseases producing them, of mechanical methods used in their treatment, of mechanical appliances and the indications for their use. This was the period to which I have already alluded and in which the dominant idea was *the application of mechanical principles and methods to the correction and cure of the deformities and diseases of the motor apparatus of the body.* However, the scientific ferment was early at work. Already, in the second volume, we find "An Experimental Study of Distraction of the Hip Joint". This was by Dr. E. G. Brackett, now Honorary Member of the Association and, since 1922, the editor of *The Journal of Bone and Joint Surgery.* Nine years later, we find R. W. Lovett, in his address as President, calling for more investigative work and the study of pathology. In this same volume is included a paper by the talented E. H. Nichols on the pathology of "Tuberculosis of Bones and Joints". From thence forward, even though slowly at first, we observe an increasing interest in the study of the motor apparatus in its mechanical implications, their relation to physiological function, and those departures from it which bring people to the orthopaedic surgeon. Lovett, himself, made a lasting impression by means of his studies on the mechanics of scoliosis.

It must here be observed that the approach to scientific methods of research with respect to the motor apparatus had been made quite a long while before the beginnings of Orthopaedic Surgery in America, by European workers who had no such specialized interest. Such is the pioneer work of Weber on the mechanics of human locomotion, dated 1836. Investigative effort in the sphere of orthopaedic interest had been undertaken in Germany, in Italy, and in other European countries quite a few years before it was in evidence on this side of the Atlantic. During my own student days abroad, a very strong impression was made upon me by the work of Julius Wolff on the architecture of bone. While his studies have not had the practical application to which he had considered them predestined, their significance has been both misinterpreted and undervalued, in my opinion. To summarize the meaning of Wolff's work in the words of Murphy, that "the amount of growth in a bone depends upon the need for it", gives a superficial and false notion of what Wolff really tried to show,—what many informed persons today believe that he succeeded in demonstrating, others to the contrary notwithstanding. Had it been said that Wolff had merely shown that bone is a living material which responds to function, both normal and abnormal, in a manner analogous to that displayed by all of the other body tissues, the

simplification would have had a better justification. Such a statement, however, conveys a conception entirely different from that of Murphy. It is at least correct, even though inadequate.

The tenth decade of the nineteenth century brought with it a discovery which was to exert an influence of the most profound character upon the development of Orthopaedic Surgery. This was the roentgen ray. Its practical application in medicine really began about 1900. The result was a change in the diagnosis of bone and joint lesions which was very far-reaching in so far as it brought about a degree of accuracy hitherto unattainable. But it did much more than this in making possible the recognition of conditions with which we had been until then totally unacquainted. I need only to speak of such conditions as epiphysiolysis of the upper end of the femur, the various forms of osteochondritis, and the identification of lesions which before that time it had not been possible to differentiate from tuberculosis. Now of admittedly great value and of constant employment in every department of Medicine and Surgery, one feels justified in saying that the influence of the roentgen ray has been nowhere so great in bringing about diagnostic accuracy and in changing the therapeutic trend as in Orthopaedic Surgery. It has been the means of making possible a wholly new line of experimental research which has still very far to go. It has not only told us with much more exactness what is required to be done, but it has given us a measure, of unexampled value, of what has been accomplished. Most significantly, however, it has added greatly to the scientific stature of the orthopaedic surgeon. He has had to become an accomplished interpreter of the roentgen-ray picture. Viewing the various permutations of bone structure and of other tissue changes, as produced by disease and injury, he has become a better pathologist through having to reconcile these changes with their underlying processes. That with this new acquisition there has also come a great number of entirely new doubts, calling for resolution, is easily comprehended, and progressive orthopaedic surgeons are today applying themselves vigorously to this task. The point of it all is that this one factor has, within a few years, completely changed the outlook of the orthopaedic surgeon, as well as his practice. The accompanying disappointments must act in the end to elevate the standards of his work. The roentgen ray has made of the orthopaedic surgeon much more of an operative surgeon than he had been before, for it has shown him that many things which he had been trying to do in a so called "conservative" or non-operative manner could be accomplished more quickly, more comfortably, or, best of all, more effectively, in this way. Still more vital is it that he has thus learned to do things by open operations which would otherwise have been impossible.

This much more frequent recourse to operative methods is, therefore, the next trend of evolutionary nature to be taken into account. According to our preapprehensions, it may be looked upon as a step forward or, on the other hand and by the conservative "die-hard", as one in

the opposite direction. It is my contention, however, that he is not less "orthopaedic" who has become more "surgical"; he is not to be held as having surrendered his time-tried accomplishments who has changed his perspective by reason of increased knowledge and experience. What has been his in the form of mechanical contrivances and of physical therapy has not been lost to him because he is trying to put things in their proper places. He is rather to be lauded for making the effort. To be censured is he, only, who regards operation as "be all and end all" instead of looking upon it as a desirable step in the treatment of his patient. I need say nothing of him who operates with an eye to his own advantage. It has always been my contention that Orthopaedic Surgery is a distinct discipline in Surgery; but never anything but Surgery. To limit the use of the term "surgery" to operative methods with knife and other instruments involving blood loss is to commit a definite solecism.

In its oldest connotation, Orthopaedic Surgery was concerned mainly with the prevention and correction of deformity. This idea was always associated with the skeleton and its components, since it is these intrinsically which give form to the body. Thus, the bones have had the foremost place in the vision of the orthopaedic surgeon and not seldom to the neglect of the rôle which is played by the muscles and other soft tissues, a rôle which is frequently of dominating importance. The demonstration of this fact by the great Duchenne has had a directing influence whose importance cannot be too greatly emphasized. However great the preponderance of the skeleton in the minds of the earlier orthopaedic surgeons, they did not busy themselves with the acute lesions and injuries involving it, but only with their objectionable consequences. With fresh fractures they were not occupied. Soon following upon the advent of the roentgen-ray era, this situation began to change and for reasons not difficult to understand. The roentgen ray brought with it that same precision in the diagnosis and treatment of fractures that it contributed in the case of disease in bone or joint. It also made possible the study of fractures, not simply as wounds of bones,—as solutions of continuity which require to be healed, as it were. Every fracture now presented itself as a potential threat of a continuing disturbance of the human mechanism such as the orthopaedic surgeon had been studying hitherto, but always after the fact. If he had now before him the terms of the problem with a new accuracy, he had also an insight into the solution of it and it appealed to him that he was himself particularly endowed with those attributes which were specifically demanded. He felt that he possessed them by reason of his own peculiar training and experience. There followed now an active participation by orthopaedic surgeons in the treatment of fresh fractures. It may be said with confidence that the results have not been disappointing. The contributions which have been made by orthopaedic surgeons in this field have been notable and their proficiency is being generally acknowledged. In some of the leading medical schools, the teaching of fractures is now assigned to orthopaedic surgeons. This but cor-

responds to an assumption of their responsibilities in full measure. However, it must be realized that the treatment of fractures must be a prominent part of the equipment of every general practitioner, as well as of every general surgeon. In ordinary practice neither of these groups should have fractures of ordinary kinds separated from their work, but the orthopaedic surgeon should be marked with an accentuated proficiency in this field, especially in cases where the mechanical problems are complicated and in which unusual and appropriate skill and experience are called for in respect of mechanical design and application. *This, too, is surgery.*

From what has been said, it must be obvious that there has been a significant shift in the attitude of the orthopaedic surgeons since the time of their integration as a group. It involves a departure from the original emphasis upon the application of mechanical methods in treatment as the point of primary importance. In consonance with the present conception, we might better point to the mechanical and motor functions of the human organism as occupying the foreground. If the statement accords with fact, it implies a shift in position of no slight significance. Perhaps a more fitting statement would now be: Orthopaedic Surgery signifies the application of surgical methods to the injuries, diseases, and dysfunctions of the motor apparatus of the body, with especial regard to its preeminently mechanical faculties. The groundwork for such an attitude was laid quite long ago. It has been asserted repeatedly that every mechanical principle employed by man in his external relationships is to be found exemplified in his own body. However, only since the early part of the nineteenth century have there been serious attempts at the study of the human body as a motor mechanism. Such are the products of the Weber brothers, Fick, Roux, Wolff, Ghillini, Lovett, Goldthwait, Steindler, and others. The subject is difficult and we should not be surprised to find that there have been aberrations from scientific method. If the mechanistic basis of many health disturbances has been almost ignored until recent years, neither will it do to employ such a theory upon grounds of purely morphological character; nor is it permissible to attempt the explanation of everything in a manner which, even here, might be termed "chauvinistic". The kinesiology of the framework must be given due consideration and this will involve us in a most complicated study. It is a study for which the fewest surgeons are qualified. It is alluring to make interesting morphological observations fit into a clinical picture, but it is very important to avoid the great error of unscientific method,—the error of trying to make our findings fit in with preconceived notions. It is a mistake which Bacon, himself, committed upon occasion. Having projected a new (an inductive) method of philosophical reasoning, he did not hesitate to abandon it incontinently when it seemed to his advantage. To study the mechanism of the body with a purpose primarily utilitarian, to investigate with the ultimate purpose of proving thereby something which one had previously settled in his own mind, this is un-

scientific. I need not say here that it is liable to lead one into error, and afterward to give the appearance of having followed a delusion. It is, by no means, always easy to avoid.

THE WORLD WAR AND ORTHOPAEDIC SURGERY

The World War had a great influence upon Orthopaedic Surgery, especially in Great Britain and in the United States. There need be no attempt to deny that the orthopaedic surgeons of the United States had to have some of their early enthusiasm dampened by learning that the rôle which they were to play was not that which they had, at first, conceived it to be, even as they had afterward the opportunity to learn that their place in the whole scheme of rehabilitation was not permitted to become what it might and should have been. But it did become necessary for the general surgeons to acknowledge that here was a group the most of whom were surgeons equal to themselves, even though they were smaller in number and had a differing view-point. The general surgeon came to appreciate, perhaps not too willingly, that this group had accomplishments which were very valuable and which were not his, nor in his ken. "Splint them where they lie!" became a watchword in the treatment of the most serious of war fractures. It was an orthopaedic contribution which did more than to improve fracture treatment. It had an undeniable effect in reducing mortality, as may be shown convincingly by the records. On the other hand, by reason of the wider contacts which military experience brought to orthopaedic surgeons, reciprocal relationships with their colleagues, of more intimate nature than civil life had furnished, were established; perhaps with professional problems more significant than those which had previously been posed to them. They returned from military to civil life with their own professional concepts greatly expanded. It seems fair to say that very few of them resumed their civil occupations without profound alteration in their attitude toward their professional activities and toward their colleagues. One can hardly resist inquiring whether the archaic institution of war was necessary to develop a balance in such relationships? And if war experience produced some such beneficence in addition to its horrors and the brutalization of men without recompense, wherein lay the element of good and how can this same factor be found in time of peace? I cannot resist the feeling that the thrust into the background of the element of economic competition played a significant part, even though I am not expecting everyone to agree with me when I say it. This is not to be taken as an argument against economic competition, since I am a sincere believer in its importance,—an importance which I think it will continue to have until people come into the world with their natural endowment equalized, or their human nature sublimated. I shall not follow the inclination to carry further an economic discussion—I know my incompetence. This inclination is but the expression of the belief that, when the economic element assumes predominance in any medical mind, the professional ideal

is almost bound to sink in proportionate degree and the approach toward being a time-server becomes dangerous.

SIR ROBERT JONES

Nowhere in this discourse would there be a better place to make acknowledgment of our debt to that great man in whose memory this lecture is given. Known to his compeers of all nations for his remarkable personal qualities, as well as his high professional attainments, long before the World War, it was the War nevertheless which gave to Sir Robert Jones his greatest opportunity. It is equally true that, of all men, he was the one to whom it should have come. It was a generous fate that would have it so. For, in respect of professional accomplishment and executive ability, together with a native tactfulness, geniality, and kindness of spirit which served to magnify greatly the potency of these primary qualities, he had no equal. I cannot forget a conversation with him on a beautiful moonlit night in the summer of 1908. Sitting in the park adjacent to his home in Liverpool, he did not hesitate to give expression to his breadth of view in professional matters and to make plainly evident that utmost catholicity of spirit which was his. All homage to him!

THE SOCIAL POINT OF VIEW

From the time when the identity of the orthopaedic surgeon became recognized, the care and the rehabilitation of the cripple has been his particular province. This is true of both the child and the adult cripple. Today, this work constitutes a major activity of social service in most civilized countries. It is easy to understand that this is due in the first place to the efficient service which orthopaedic surgeons have been able to render. It had to become palpably manifest after a time, but this is by no means enough to say. A definite struggle had to be made, to begin with, in order to obtain opportunities to show what could be done for these beneficiaries, and a public interest had to be developed if effective work was to be done upon a sufficiently large scale. In undertakings of this kind, it is usual that, after something tangible has been accomplished, the results are published in order to secure augmentation of financial resources. In such publications one usually finds a sentence or a paragraph making mention of "the devoted service which the orthopaedic surgeons have given". The fact is that, in every country which has developed facilities for the aid of indigent cripples, the orthopaedic surgeon will be found in the background, first winning respect by excellent professional accomplishment. Afterward, he has often exhibited the quality of leadership in gaining the cohesion of his colleagues, as well as the adhesion of a socially-minded lay group. Willingness to avoid personal publicity is but another evidence of sincerity of purpose and of true leadership. Nowhere has this been better shown than in the United States; the State has been led to acknowledge its solicitude and responsibility by numerous legislative enactments. First and foremost, we encounter the name of Dr.

Arthur J. Gillette, of St. Paul, Minnesota, who was able to secure the first of such legislative response in the establishment of the Minnesota State Hospital for Crippled Children, in 1887. To him there is due this expression of praise and gratitude, whether or not we find ourselves in agreement that this is the best way of solving the problem. Orthopaedic hospitals, in some number, there had been before this time. They, too, owed their founding to the same kind of foresight and leadership, but they were supported privately, and were located principally in metropolitan centers, and they responded chiefly to local needs. In 1915, Dr. Michael Hoke secured the interest of the local Scottish Rite Masonic fraternity and the consequent organization of its Hospital for Crippled Children at Decatur, Georgia. Following this, there have been fruitful interest and action on the part of numerous lay organizations, be they of fraternal or of purely philanthropic nature. Tribute must here be paid to Mr. Edgar F. Allen, of Elyria, Ohio. Through his devotion and unceasing effort there was organized the Ohio Society for Crippled Children and afterward the International Society for Crippled Children, Inc. With the support of the Rotarian organization, Mr. Allen succeeded in having enacted by the Ohio legislature the first provision in the United States for a state-wide organization in behalf of indigent crippled children. This has been looked to as a model for similar plans in other states. There followed the organization of the Shriner's Hospitals by this society of Masons. Other laymen have been effectively active in behalf of the crippled and disabled; worthy of especial mention is Mr. Douglas C. McMurtrie of New York. It is surely pardonable, however, if we here revert to the fact that practically all of this admirable accomplishment may be basically credited to that which Orthopaedic Surgery has made possible, as demonstrated by the unselfish work of its votaries. Today we witness the recognition of its importance in the specialized inclusion of the cause of crippled children in the Social Security Act of Congress and the precedent powerful and sympathetic interest of President Franklin D. Roosevelt. In other countries, similar things have been going on. As a motivating force we always find the orthopaedic surgeon. One may not fail to mention the name of Sir Robert Jones in Great Britain, and Hoffa and Biesalski in Germany. While only the leaders have been mentioned by name, it is evident that Orthopaedic Surgery has become an important force in human salvage and one which today's civilization will not consent to relinquish.

CONCLUSIONS

I am convinced that Orthopaedic Surgery represents today a development which is desirable and needful, for the good of humanity. It calls for a high degree of specialized training, both of a scientific and of a practical nature. It demands talent and personal devotion both in kind and amount such as will justify men who possess them to dedicate their lives to this work with the assurance that in so doing there may accrue to them the most ample satisfactions. Orthopaedic Surgery is in its essence a

combination of the mechanical and the operative in surgery, but in its quintessence it is and must continue to be surgery. A proper blending of these two factors is required if we would avoid unfulfilment on the one hand or the infliction of harm on the other. If Orthopaedic Surgery was originally too much concerned with the external use of mechanical appliances, this was largely so because operative surgery had come to be noxious and even destructive in its definitive effects and in this particular sphere. It is not surprising that a movement to the opposite extreme ensued. Today, we find it necessary to be armed with all resources, both operative and non-operative, as well as to know how to mingle them skilfully as regards time and manner. The emphasis of Orthopaedic Surgery today is upon the mechanism of the body's motor apparatus, and what may be done with it and for it. It must be possible to employ such means as will be to the greatest advantage of the patient, be they operative, or non-operative. Orthopaedic Surgery has made valuable contributions to knowledge in its field, both in regard to the normal and pathological physiology of the motor apparatus and in respect to the employment of non-operative and operative methods of help. It has a mission to accomplish much more. For this, ample encouragement and opportunity must be afforded. It is necessary that Orthopaedic Surgery be taught to undergraduate students as a discipline in Surgery, just as Gynecology and Urology are taught. Its teachers should have appropriate academic recognition, as befits their accomplishments and proper functions. While this should imply dignified rank, this cannot be specified. Academic position must depend largely upon a personal and individual factor. However, it should be held that the place of Orthopaedic Surgery in the curriculum may not depend upon the opinion or the whim of any man. Happily, it seems unlikely that the demand will be made that it do so. The place which Orthopaedic Surgery has been able to assume, both in its professional and general social relationships, is dependent upon an idealistic attitude on the part of a great number of practitioners and upon their effective service. It must be assumed possible for the general surgeon who is a skilful operator to learn to do the most difficult orthopaedic operations in an acceptable manner; just as it is possible for a well-trained orthopaedic surgeon to accomplish the same thing in the case of abdominal or other operative measures which are granted to belong within the realm of general surgery. Certainly, the financial consideration should never be the factor to decide what shall be done. However, he who enters the orthopaedic field upon occasion only is likely to misconceive the place of operations in the scheme of things which the orthopaedic patient requires, just as he is unlikely to be provided with the training, the routine, the organized personnel, and the armamentarium which will enable him to do full justice to those who require this kind of service. While many persons still live under such conditions as make it imperative for them to forego highly specialized service in many departments of Medicine and Surgery, the standards of our time call for a large number of

able and well-trained men who are thoroughly equipped in the fundamentals of General Medicine and Surgery, but who devote their lives to the practice of Orthopaedic Surgery. Nothing less will fulfil the needs of our present-day society; nothing less will answer its demands acceptably.

Doubtless, many of you have had pleasure and profit from the reading of Stephen Paget's "*Confessio Medici*" and it is likely that you have been touched, as I have been, by his concluding words. I beg permission to repeat them: "He has not fulfilled his ambition to be at the top of the tree; but he can still congratulate himself that he is on a branch. The natural dignity of our work, its unembarrassed kindness, its insight into life, its hold on science—for these privileges, and for all that they bring with them, up and up, high over the top of the tree, the very heavens open, preaching thankfulness. Circle above circle, the reasons for it are established, out of the reach of words." This was an expression of the author, having in mind the practice of the medical profession generally. I became acquainted with these words quite long ago and they have remained fixed in my mind with an appeal of indefinable strength. More remarkable sentences than these are to be found in this charming book, but these closing words impress me with their appositeness, not simply in respect of our common profession, but particularly to that part of it to which my own career has been dedicated. I commend these words to the thought of every orthopaedic surgeon. They might well conclude his testament.

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GENERALIZED OSTEOCHONDRODYSTROPHY

The Eccentrochondroplastic Form

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That there exists a great need for a systematic grouping or classification of the various chondrodystrophies and osteochondrodystrophies is apparent to any one who grapples with the problems of diagnosis.

A classification of these conditions suggested by Henry L. Jaffe, pathologist at the Hospital for Joint Diseases, distinguishes true clinical forms corresponding to pathological entities and serves to clarify the problem considerably. It also seems to be of inestimable value in the roentgenographic analysis of these diseases.

According to Jaffe, the osteochondrodystrophies may be divided into two main groups: (A) the localized and (B) the generalized. The localized are neither congenital nor hereditary; furthermore, their onset is preceded by apparently normal development of the region or regions which subsequently become affected. On the other hand, the generalized osteochondrodystrophies are hereditary, and clearly show a predilection for certain families. They begin to make their appearance very early in life and may even be congenital.

The two main groups of osteochondrodystrophies may be subdivided as follows:

A. Localized osteochondrodystrophy
   1. limited to one epiphysis (as Legg-Perthes disease of the capital femoral epiphysis)
   2. limited to one epiphysioid bone* (as Köhler's disease of the tarsal scaphoid)
   3. limited to a few epiphyses or epiphysioid bones
      a. involvement of both capital femoral epiphyses
      b. involvement of more than one vertebral center, or
      c. involvement of one or more epiphyses together with one or more epiphysioid bones.

B. Generalized osteochondrodystrophy
   1. leading to dwarfism because of failure of growth of cartilages (achondroplasia)
   2. leading to the appearance of osteochondromata at the metaphyses, with distortion of the growth region of the bone (dyschondroplasia)
   3. associated with irregular development of epiphyses and epiphysioid structures (eccentrochondroplasia).

* Carpal and tarsal bones which develop like epiphyses from centers of ossification.

By the adjective "eccentro", Jaffe refers to the fact that the epiphysis or epiphysioid bone in eccentrochondroplasia does not develop from a central nucleus of ossification, but from the multiple eccentric centers of ossification so clearly shown in the roentgenograms. Thus the term "eccentrochondroplasia" has been coined not to add to the already overburdened nomenclature, but to make clear the distinction between achondroplasia, dyschondroplasia, and this third form of generalized osteochondrodystrophy (the subject of this paper), which is a separate entity and not a "*forme fruste*" of either or of both of the others.

However, in regard to the generalized osteochondrodystrophies, it must be recognized that mixed forms (wrongly classified as "*formes frustes*") occur, as for instance when the bones of an upper extremity show both achondroplastic and dyschondroplastic features. Furthermore, dyschondroplasia may be unilateral.

LITERATURE

In 1925 and 1926 Silfverskiöld reported two instances of a bone dystrophy which occurred in a mother and in her son, in whom the epiphyseal cartilages were deformed and the ossification was irregular. He classified the condition as a "*forme fruste*" of chondrodystrophy with malacic bone changes. In one case he considered the malacic changes to be of the Calvé-Legg-Perthes type.

FIG. 1

Case 7. Patient, aged five, showing attitude and deformities. The standing height is 38 inches as compared with 44 inches which is the normal height for a boy of this age. This dwarfism is largely due to a shortened trunk; the sitting height is four-fifths of the normal measurements for his age.

The head is normal; the neck is short. The chest has a definite pigeon-breast deformity. The marked kyphosis of the lower thoracic region further increases the anteroposterior diameter of the chest. The abdomen is slightly protuberant. The elbows and wrist areas are enlarged. There is marked general muscular and ligamentous hypotonia, although to a lesser extent than in the older brother. The coxa vara, the genu valgum, and the pes planus contribute to the waddling gait.

Grudzinski (1928) subsequently described what is obviously the same disturbance as a "new disease related to chondrodystrophia foetalis". He divided the atypical forms of achondroplasia into three groups: (1) partial, (2) abortive, and (3) clinically variable. In the third group he placed the cases described by Silfverskiöld in which there were some of the signs of achondroplasia, but in which the bone changes resembled the disease known as "osteochondritis deformans juvenilis". In two of his three cases the disease was generalized, while in the third the changes were localized to both arms. Grudzinski was of the opinion that these were not cases of atypical achondroplasia, but that they belonged to a separate entity, in some respects similar and related to achondroplasia, but showing the most striking change in the cartilaginous ossification of the epiphysis. He suggested that the condition be termed "osteochondropathia multiplex (Silfverskiöld's disease)".

In 1929, Morquio described a form of familial osseous dystrophy which occurred in four of five children in the same family. He stated that he was unable to find similar cases in the literature available to him. In his report he clearly differentiated this disease from achondroplasia. Since then, this curious disease is frequently associated with his name. Most of the cases reported in the literature before Morquio's description and after (as for instance those described by Ruggles, Meyer and Brennemann, Barnett, Davis and Currier, etc.) have been of children and adolescents before the epiphyses had fused; in other words, in the florid stage of the disease when the changes are strikingly characteristic.

OBSERVATIONS

Through the courtesy of two of the author's colleagues it has been made possible for him to study the

FIG. 2

Case 6. Patient, aged ten. The characteristic posture and deformities of the chest, the spine, and the extremities are clearly shown. The standing height is 46 inches (that of a normal ten-year-old boy is 59½ inches). The long, narrow face and head rest on a very short, stocky neck. Although the shoulders are narrow, the prominent sternum, the pigeon breast, and the thoracic kyphos increase the anteroposterior diameter of the chest. The chest circumference is 27½ inches (that of a normal boy of ten years is 26½ inches).

The trunk is greatly shortened by the marked kyphosis. The upper extremities are relatively long with large, deformed elbows and flattened wrists. There is a well-developed genu valgum and a marked degree of pes planus. The muscle tone is weak, but there is good muscle coordination. The joints are extremely hypermotile. The hands permit such a pronounced degree of hyperextension as to allow the fingers to touch the forearm. There are none of the outward signs or deformities of achondroplasia.

FIG. 3

FIG. 4

FIG. 3 AND FIG. 4

Mixed type of disease.

In Fig. 3 (Case 7, aged five) the carpal nuclei have a normal aspect and contour, although in Fig. 4 (Case 6, aged ten) they are definitely deformed, but with a somewhat sharp contour. There is fusion of the trapezium and the trapezoid. At the age of ten there is definite delay in the appearance of the scaphoid on the left side.

The nuclei of the heads of the metacarpals are enlarged and, although the epiphyseal surfaces are fairly sharp, the joint surfaces are irregular, due to the presence of minute points of ossification. With the exception of the first metacarpal, the proximal ends are pointed and the axes of the bones are directed toward each other like the ribs of a fan (*"main-en-trident"*). The diaphyses are broad and short with a distinct distal flare. The terminal portions of the terminal phalanges are bulbous.

The juxta-epiphyseal line is clean-cut and sharp and the zone of temporary calcification is a single sharply defined dense line, somewhat irregular, but nevertheless clearly traceable. The ossification of the epiphysis of the lower end of the radius and of the ulna is by punctate centers. The juxta-epiphyseal edge of the diaphysis is convex, and the ulnar and radial surfaces are directed obliquely toward each other as in achondroplasia.

adults of a family in which several children showed the florid changes of the disease in question (which is being classified as eccentrochondroplasia). It has thus become possible to trace the natural history of the disease. As a result of this it would seem that many hitherto unexplainable lesions in the joint ends and certain deformities in the vertebrae in the adult may be the end results of this disease. This form of osteochondrodystrophy apparently goes through several stages,—a latent, a florid, and a stage of healing with its aftermath of deformity.

The cases of Morquio, Ruggles, Brailsford, and others show that this is definitely a hereditary familial affection; that the affected subjects have a definite physical habitus; that the blood of the patients is in no way abnormal; that the disease has no relation to syphilis; and that the changes in the bones are characteristic.

The cases on which this study is based come from two Italian families.

Group I, which the author was permitted to study through the courtesy of Dr. Philip Palew of the Department of Orthopaedics, consists of a mother and six children. The parents were not related. The mother and four children show the changes of the disease.

CASE 1. The mother is fifty-one years of age and is the third child of nine. She is of normal intelligence. Up to the age of twenty-five she had occasional pain in the hips, the knees, and the ankles. At present she is free from all symptoms except an inability to go up and down stairs with ease. She was married at thirty years of age and has had six pregnancies with normal deliveries.

Her first two children were outwardly normal. They were not examined roentgenographically.

CASE 2. The third child, a male, aged nineteen, began to complain of pain in the hips and the knees at the age of four. At this time deformities of the lower extremities were noticed.

CASE 3. The fourth child is a female, aged seventeen. At the age of two it was noted that her gait was peculiar. At the present time she does not suffer pain or disability.

CASES 4 AND 5. The fifth and sixth children were male twins, twelve years old. One child complains of tiring easily and has pain in the hips and the knees after exertion. The other has no complaint except in regard to his gait.

Through the courtesy of Dr. Rosa Lee Nemir, of the Department of Pediatrics, the writer is permitted to add a second group which consists of two brothers in a family of five children. The parents are in no way related. The family history is negative. There are two boys and a girl who are normal.

CASE 6. This patient is a boy of ten years, born at term with instrumental delivery. The child was born with a "crooked left arm", which was put in a splint by a doctor when the patient was nineteen days old. The arm remained in a splint for six months.

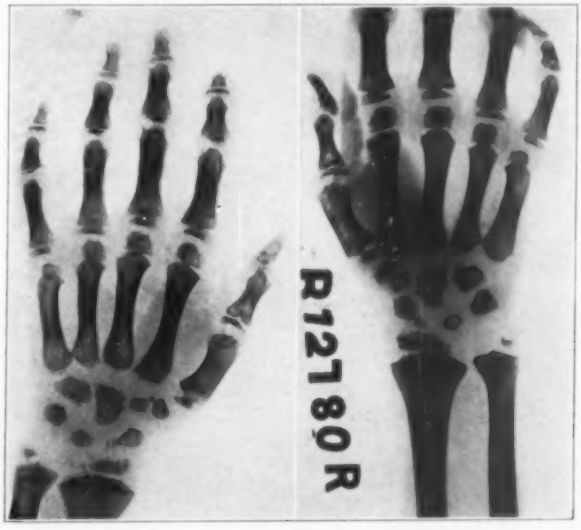

FIG. 5-A FIG. 5-B

Cases 4 and 5. Patients, aged twelve. There is marked irregularity in the contour of the nuclei of ossification of the carpals. The trapezium evidently has two nuclei which are in the process of fusion. A similar condition exists in the scaphoid. Note the notched or scalloped contours particularly of the os magnum. The nuclei for the heads of the metacarpals show a ragged contour with spicule formation. Their bases are not pointed and clear-cut, but ragged and indefinite in contour. The first metacarpal (Fig. 5-B) shows a double nucleated distal epiphysis (Morquio, Ruggles, Brailsford). Instead of being smooth and rounded, the distal ends of the phalanges are irregular and serrated with spurlike projections on the ulnar side. The tips of the terminal phalanges are broadened and bulbous with a coarsely meshed cancellous structure. The epiphysis of the lower end of the radius and of the ulna is an irregularly contoured disc made up of fused punctate nuclei. The juxta-epiphyseal edge of the metaphysis is convex and irregular, due to incompletely formed, incompletely cancellated, and crowded lines of temporary calcification.

TABLE I

GROUP I

Case	Member	Sex	Age (*Years*)	Involvement
1	Mother	Female	51	General
	First child	Female	?	?
	Second child	Female	21	None
2	Third child	Male	19	General
3	Fourth child	Female	17	Partial
4	Fifth child	Male	12	General
5	Sixth child	Male	12	General

TABLE II

GROUP II

Case	Member	Sex	Age (*Years*)	Involvement
	Mother	Female	?	?
6	First child	Male	10	General
	Second child	Male	9	None
	Third child	Male	7	None
7	Fourth child	Male	5	General
	Fifth child	Female	3	None

FIG. 6

Case 1. The permanent adult deformity of the hands is seen in the relatively large, deformed, and flattened metacarpals. The short and deformed terminal phalanges of the first finger are a rather constant finding.

Except for this crooked arm, nothing abnormal was noted until the boy was two and one-half years old, when a deformity of the legs was observed. Previously able to walk well, he now began to experience difficulty. Later a bowing of the legs was noted, which grew progressively worse until the age of six. Since then there have been only slight changes. Shortly after this, "pigeon breast" developed. At approximately three and one-half years, a definite kyphos appeared. Finally the arms showed developmental deformities. The mother states that the boy grew rapidly as a baby, but after these deformities appeared he seemed to grow shorter instead of taller, and since five years of age he has not grown in height.

CASE 7. This boy was five years old when first seen in 1932 and was the fourth child in a family of five. He was born at term, after a normal delivery without instrumentation. He showed no signs of birth injury. At seven months a de-

FIG. 7-A FIG. 7-B FIG. 7-C

Cases 4 and 5. The tarsal bones are very markedly deformed and osteoporotic. The contours are extremely irregular with crenations, indentations, and spicule formations. The proximal ends of the metatarsals are irregularly flattened without any sharp contour. The diaphyses are of normal length, the distal ends being somewhat crenated. There are several pin-point nuclei of calcification in the cartilage at the head of the first metatarsal bone (Fig. 7-A). The terminal tufts of the phalanges are pointed.

formity of the back was noted, and a back brace was applied for six months without improvement. At three years the child developed a deformity of the legs which has progressed to the present time. The mother thought that the child had grown normally in height until recently.

The disease is not generally recognized until the child begins to walk, although the characteristic roentgenographic signs become apparent with the onset of ossification of the epiphyseal cartilages. The disease is self-limited. The florid stage (even without treatment) gives way to a healing stage. The outward deformities which may have developed gradually become less marked with the approach of puberty, and in the adult no outward evidences of the disease except the genu valgum and pes planus are apparent.

FIG. 8

Case 1. Adult lesion. Note the enlargement of the heads of the metatarsals and the flattening of the distal ends.

Outward Signs

The most striking outward deformity

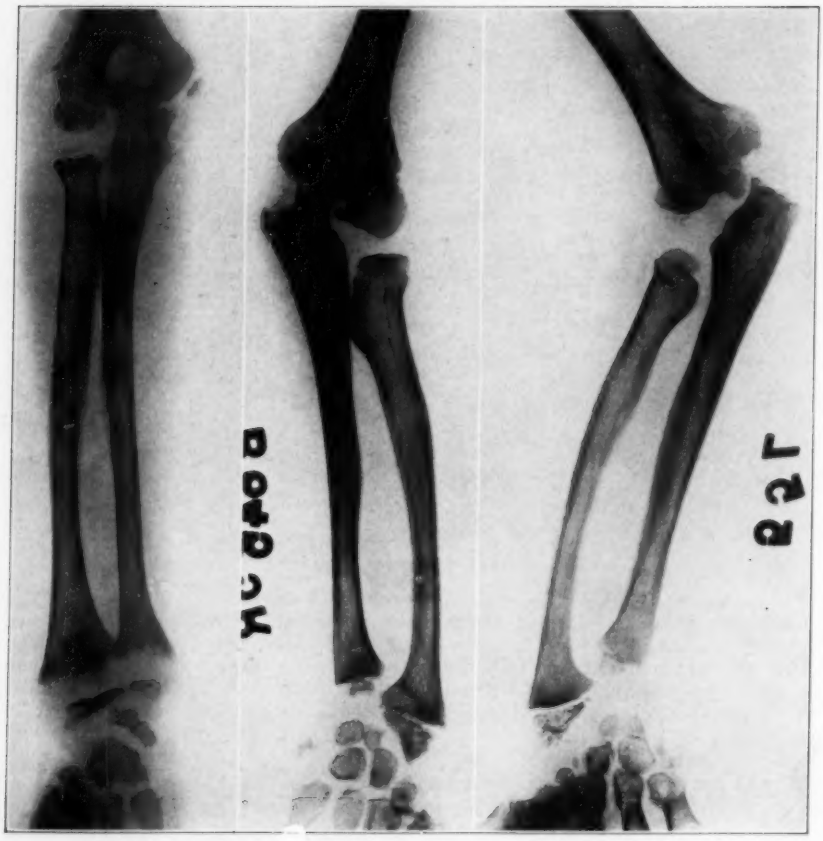

FIG. 9-A FIG. 9-B FIG. 9-C

Fig. 9-A: The forearm in a case of rickets showing the appearance of the epiphyseal end. Note the contrast in Figs. 9-B and 9-C.

Figs. 9-B and 9-C: Case 6. The epiphysis of the lower end of the radius is of pyramidal shape with punctate nuclei of ossification about it. The metaphyseal contour is sharp and clearly defined. The epiphyseal nucleus of the lower end of the ulna consists of pin-point nuclei. There are definite malacic changes in the shafts. The ossification of the capitellum and trochlea of the humerus shows a similar deformity. There is a definite disturbance in the relationship of the radius to the ulna. The olecranon process is deformed; the coronoid process is blunted, and the radial head does not articulate with it. The interosseous space is unusually widened. The deformity resembles that of achondroplasia.

FIG. 10

FIG. 10

Case 5. The changes in the bony nuclei for the head and the greater tuberosity are characteristic, but the striking change is the deformity of the glenoid process whereby it seems devoid of a glenoid cavity.

FIG. 11

Case 1. The adult type of lesion. Found by x-ray examination in an individual without any outward deformity, these changes in the bones of the shoulder joint would be difficult to explain unless the genesis of the disease was understood. Not only is the shaft bowed and the head incompletely formed and flattened, but the glenoid process is incompletely developed and the glenoid socket is very shallow.

FIG. 11

is usually a thoracic kyphos associated with marked prominence of the sternum. (See Figures 1 and 2.) These changes in the thorax and in the vertebral column produce a characteristic attitude and give the trunk its striking form. Viewed from the front, the head seems

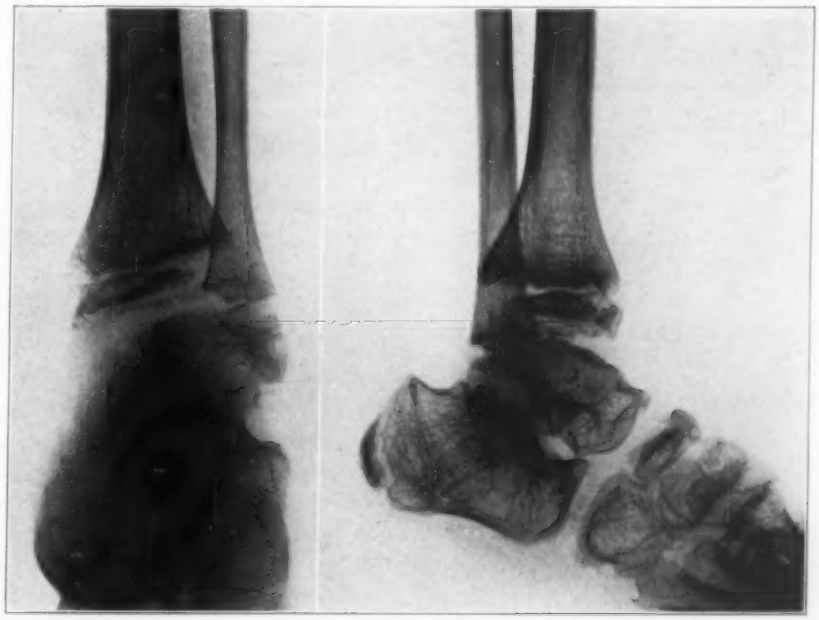

FIG. 12-A FIG. 12-B

Case 4. Although deformed, the tarsal bones nevertheless have fairly sharp and definite contours, but are markedly osteoporotic with an irregular and coarsened cancellated structure. The bone center in the epiphysis of the posterior part of the os calcis arises from many nuclei which fuse and the ossification proceeds in this manner in the epiphyseal cartilage, giving this ossifying epiphysis an irregular outline.

The malacic changes in the astragalus and in the lower end of the tibia and of the fibula are well shown. The deformities of the tarsus are maintained through life. The epiphyseal nucleus of the tibia is often bifid, the diaphyseal end is scalloped, and there are fragments of several zones of temporary calcification.

FIG. 13

Case 2. The permanent deformity is also shown as a flattening of the astragalus associated with a shallow tibial mortise.

to rest on the thorax, so that the chin extends over the sternum. The pelvis is tipped forward. The hips are thrown back, the thighs are bent forward, and the legs are flexed on the thighs and are in the position of extreme genu valgum. The feet are flat and everted. The hands have the trident form. The fingers are short and stubby and have a tendency toward lateral deviation. With the arms at the side, the fingers reach almost to the knees. There is an apparent enlargement of the extremities at the joints and a peculiar laxity and hypermobility.

Because of the knock-knee, the flat-foot, and the malformation of the vertebral column, the gait resembles that of one affected with congenital dislocation of the hips.

The genitals are normal. The intelligence is normal. The reflexes are normal. The blood Wassermann, sugar, calcium, and phosphorus are, as a rule, normal.

Roentgenographic Changes

The characteristic feature of the disease is a peculiar disturbance in epiphyseal ossification associated with a malacia, which produces a definite deformity in the size and the shape of the bones, particularly in the articulating ends.

Florid Stage

The most striking changes of this stage are shown in the ossification zones. The changes usually involve all of the bones, including the vertebrae, with the exception of the flat bones of the skull. However, as in all types of generalized dyschondroplasia, the changes may not involve all of the bones to the same extent and there are cases where only a few bones are involved.

The mixed type, modified by certain achondroplastic characteristics, is apparently not uncommon. The individual bone ends have shapes

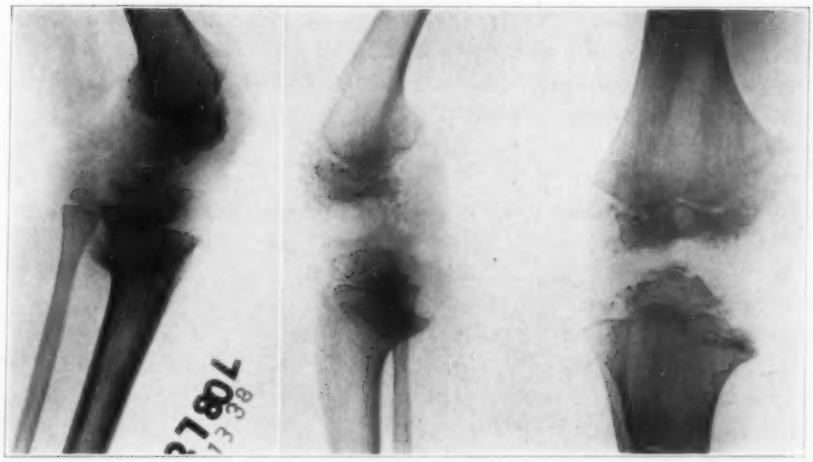

FIG. 14-A FIG. 14-B FIG. 14-C

Cases 4 and 5. The ossification of the epiphyseal cartilage by means of punctate nuclei in the outer and posterior surface of the femoral epiphysis is also shown very distinctly in the outer tibial epiphyses. The line of temporary ossification of the diaphysis is thinner than normal and irregular. The outer and upper portions of the patella show the same mode of ossification. The epiphyseal bony nucleus for the tuberosity of the tibia is not present.

The epiphysis for the upper end of the tibia is markedly pyramidal, with coarsened trabeculae. Numerous lines of temporary ossification are seen in the diaphyses. There is a deep groove-shaped depression over the inner, lateral, and posterior aspects of the tuberosity. The entire head of the tibia is bent backward. As growth proceeds, the ossification of the outer portion of the epiphysis is delayed and its contour is irregularly outlined by numerous fragments of bone.

which resemble the bones of achondroplasia. The general body deformity is, however, not present. No sharp line of demarcation can be drawn between the two types, as far as the underlying eccentrochondroplastic characteristics are concerned, although the intensity of disturbance of the cartilaginous ossification and the changes in bone structure are more marked in the pure cases of this disease. This mixed type has occasioned much perplexity as to its proper place in the classification of the congenital osteochondrodystrophies. As already stated, it was originally designated as a "*forme fruste*" of achondroplasia and even recently Snoke, in an article on chondrodystrophia foetalis, placed a case of this type of eccentrochondroplasia (Case 3) into Kaufmann's classification of achondroplasia (malacic type), where it does not belong.

FIG. 15

Case 1. Adult deformity of the knee joint. Note the flattening of the condyle, the backward extension of the head of the tibia, the coarsened trabeculae, and osteoporosis.

There is an increase in the width

of the cartilage plates. Normally, the cartilage is gradually ossified as a regularly progressive and advancing zone of ossification. In this condition the zone of temporary ossification is irregular in density, its advance is irregular and disorderly, and uneven lines are always left behind, both in the epiphysis and in the diaphysis. Small nuclei of bone are found irregularly distributed through the cartilage. As growth proceeds, these fine points of ossification coalesce, giving the main nucleus a ragged contour both on the epiphyseal side and on the joint side. After complete fusion of these isolated nuclei has taken place, the epiphyseal ends attain a smoother contour. The involved bone ends, however, are left markedly deformed in shape and diminished in size (Figs. 6, 8, 11, 13, 15, and 18).

The malacic changes involve the bone and the cartilage and produce bowing both in the metaphysis and in the epiphysis, resulting in humerus varus, coxa vara, and genu valgum. On the concavity of the bent bone the periosteum is thickened and there is osteophyte production. On the convexity the cortex is thin and porous. The compact tissue is sparse and porous. The cancellated structure is widely meshed and the lamellae are coarse.

There is no marked delay in the first appearance of the centers of ossification, but subsequent growth, fusion, and molding are slow.

The primary nuclei for the carpal and tarsal bones and the secondary nuclei for the epiphysis may appear as multiple pin points of ossification which fuse as growth proceeds, or the nuclei may appear with their usual contours, but become deformed as a result of punctate accretions as the ossification proceeds. (See Figures 3, 4, 5-A, 5-B, 7-A, 7-B, and 7-C.)

Instead of the usual more or less convex contours, the tarsal bones show concave or scalloped, hazy, double contours, to which are fused

FIG. 16

Case 7. The segments of the epiphysis for the upper end of the femur, instead of being hemispherical, are irregularly shaped plates with irregular contours. The epiphysis for the greater trochanter is deformed and irregular in outline. The acetabulum appears to be relatively large, particularly the iliac portion, and relatively shallow. The coxa vara is especially striking. The pelvis is of the anthropoid type. There is marked inward displacement of the acetabula.

small fragments of ossification. Fine spicule or spur formations extend into the cartilages. The cancellated structure is coarse, irregular, and porous. As the age advances, the bones tend to assume their normal anatomical contour, but they are smaller than normal and show definite deformities.

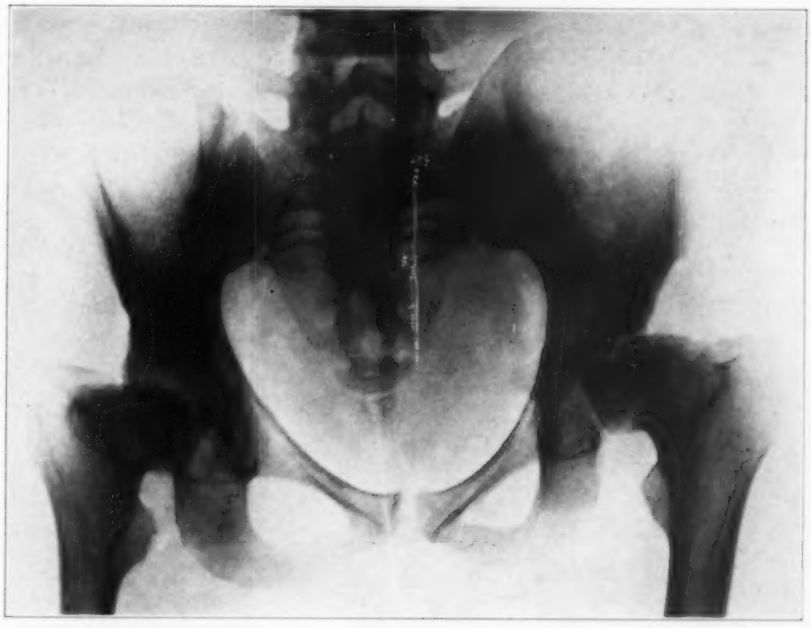

FIG. 17

Case 2. The changes found in the hip joints of the adolescent. The femoral heads are small and flattened. The neck is short and in a position of coxa vara. The acetabulum is relatively large and shallow.

FIG. 18

Case 3. Adult type of lesion. Note the large acetabula and the small femoral heads in coxa-vara position.

The normal shape and sharp contour of the nuclei of ossification of the epiphyses of the long bones are strikingly changed. The irregular punctiform ossification and the spicule formations are responsible for the irregularity in contour.

Characteristic changes are shown in the juxta-epiphyseal ends of the diaphysis. These are usually irregularly flat or convex, never concave. The zone of temporary calcification is wide and ragged or fragmented, and the immediately adjacent zone of

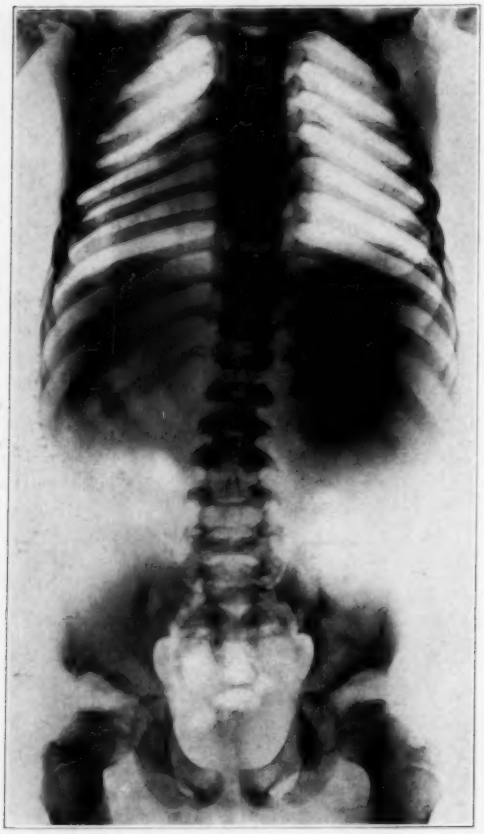

FIG. 19 FIG. 20

Case 7. The vertebral bodies of the thoracic spine show a convexity on both upper and lower surfaces, while the anterior surfaces show a blunted projection which in the lumbar region becomes sharp and pointed. It is in this area that there is the kyphos. The intervertebral discs are enlarged. The ribs are broadened at their cartilaginous ends.

cancellated bone is very coarse and trabeculated and is traversed by incompletely formed residues of unabsorbed lines of calcification.

There is a definite delay in, and in most cases an almost complete absence of, ossification of the rims of the glenoid cavity (Figs. 10 and 11) and of the acetabulum. Even when the lesions are generalized, a single bone, the fibula, may remain free from the characteristic changes. It is to be noted that in chondrodystrophia foetalis the fibula also remains

free from the disease and grows normally, and thus exceeds the tibia in its length.

In the mixed type of disease, the proximal ends of the metacarpals are pointed and the axes are directed toward the center of the carpal area. The distal ends are flaring and flattened. The bones are short and broad. This gives the hand somewhat of the "*main-en-trident*" form (Figs. 3 and 4).

When the intensity of the process is not marked, the diaphyses of the metacarpal and metatarsal bones at the ends devoid of epiphyseal cartilages show striking changes. Thus, the proximal ends of the metatarsals are ragged and irregular and have a disordered cancellated architecture (Figs. 7-A, 7-B, and 7-C). The distal ends show a peculiar crenation.

The spinal deformity is striking and characteristic (Figs. 19, 20, and 21). The bodies are flattened and the anterior contours are pointed, beak-shaped, or tongue-shaped along the inferior border. The zones of temporary calcification are dense, and spicules of bone project into the cartilaginous plate. The trabeculae of the cancelli are coarse and irregular. The intervertebral discs are wider than normal. The kyphosis is clearly seen to be due to a change in the relationship (wedging) between the lower two thoracic bodies. In spite of this deformity, the spaces in this area are not diminished in size. As growth proceeds, the sharply pointed anterior surface becomes blunted. The segments of the sacrum usually remain unfused.

FIG. 21

Case 2. Adolescent type. The vertebrae are flat and wide. The intervertebral discs are widened. There is still a slightly blunted projection from the anterior surface of the vertebrae.

The skull may be scaphocephalic or normal. The sella turcica is normal in shape and in size. The accessory sinuses are usually large.

Healing Stage

In the healing stage the tendency to the establishment of the normal arrangement and form is very marked. There is consolidation of the irregular islands of ossification and the surface contour sharpens, but neither the shape nor the size is ever completely normal. The bending and bowing resulting from the malacic changes, whether at the ends of the

bones or in the shafts, persist and the disordered ossification results in defective bone formation. This deviation is sufficiently striking to mark the bone as showing the terminal stage of the disease in the same way as the end result of marked rachitis is recognizable. Thus the ends of the long and the short bones are enlarged and flattened. The spherical heads of the humerus and the femur are deformed and are usually smaller than normal, appearing more so because of the defective neck formation and abnormally large joint space. In the shoulder, the defectively formed, shortened, and flattened head appears to articulate with a glenoid process almost devoid of a glenoid cavity. Roentgenographic examination usually reveals small femoral heads with shortened necks in coxa vara in relatively large acetabula. The deformed and flattened upper contour of the upper surface of the astragalus articulates into a deformed mortise of the tibia. The coarse texture of the cancellated bone persists.

The vertebral bodies become markedly shortened and very wide. This platelloid type of vertebra is not infrequently found in isolated cases as a single lesion and has been described as a developmental aberration. In these cases, other evidences of healed osteochondrodystrophy, when sought for, will be found.

Since in the adult the outward form of the body may no longer present any striking deformity in form or in posture, the deformity of the bones as shown by the roentgenogram has until now not been associated with this disease, but has usually been ascribed to some old inflammatory or dystrophic lesion of the Perthes variety. It is now apparent that such findings should be ascribed to the form of bone and cartilage malacia here described.

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BOUND FEET IN CHINA

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HISTORY

There is considerable difference of opinion as to the origin and history of the practice of foot-binding. A comprehensive discussion on this subject is contained in the works of Yu Cheng-hsieh (1775–1840). The most generally accepted belief is that it began with a lady named Yao Niang* in the court of Li Yu, King of Southern Tang, a great poet but a poor ruler, who reigned from 961 A.D. until he surrendered to the victorious army of Sung in 975 A.D. This view, however, cannot be accepted by critical scholars, because such a difficult and cruel practice, started by a court lady in a small kingdom in the Yangtse valley late in the tenth century, could not possibly have become a fairly general fashion by the next century, and we have indisputable evidence that foot-binding had already been commonly practised in North China by the eleventh century.**

Moreover, we have evidence to show that, as early as the ninth century, the feet of singing and dancing girls had already become quite small. The poet Tu Mu (803–852 A.D.) described a woman entertainer's feet as of "the length of a foot minus a quarter",† which is eighteen and six-tenths centimeters,‡ and as "slender and pointed as bamboo shoots" and "wrapped in embroidered silk". Another poet, Han Wo (who died about 915 A.D.), spoke of a woman's foot as being only six inches in length (which is fourteen and nine-tenths centimeters). In half a century, the length of the feet had been reduced by almost four centimeters. In the same poem, Tu Mu wrote:

"The carefree youths of Chang-an, taking advantage of her drunkenness,
Laughingly took her feet from under her skirts and exhibited them before the flowers."

This clearly indicates the existence of a tendency to play with the feet of women, a tendency which, more than imperial patronage or any other

* Yao Niang's story is found only in writings of the twelfth century. Her name was never mentioned in the two histories of the Southern Tang Dynasty by Ma Ling and Lu Yu, nor in any other works on that kingdom by contemporary witnesses.

** The poet and scholar Hsu Chi (1028–1103) wrote apologetically of a pious woman who, because of the necessity of doing hard work, "had no time to bind her feet".

† The line may be read in two ways. This reading follows the suggestion of Yu Cheng-hsieh, who held that in all ancient writings "*ssu fen*" always meant one-quarter. However, "*ssu fen*" may also mean four-tenths, in which case the length of the feet would be six inches,—that is, fourteen and nine-tenths centimeters.

‡ The calculations of the foot measure of the Tang Dynasty given here are based on "A Study of the Weights and Measures" by Wu Ta Cheng (1835–1902). One Tang inch is about two and five-tenths centimeters.

thing, was the real origin of foot-binding. In another poem, Tu Mu had these lines:

"You may allow other people to look at your dancing shoes,
But your smiles are reserved for me alone."

It seems probable that the solo dancers were the first women to have pointed shoes and to dance sometimes on tiptoes, from which have gradually come all of the excesses of the bound feet.

It is now quite impossible to assign dates to the early beginnings of this practice. Ssu-ma Chien (145–85 ? B.C.) described the dancers of his time as having long sleeves and pointed slippers, but it was not until the ninth century that we have clear evidence that the feet were already very small, and they rapidly became smaller and smaller in the subsequent centuries. Official records show that, at least during the earlier period of the Tang Dynasty (618–906 A.D.), this practice, which originated with dancers and public entertainers, was not yet adopted by the women of the Court and of the higher families.* In a country where there was no permanent aristocratic class, the fashions invariably came not from above, but from below; and the practice of foot-binding soon spread in North China and invaded even the best and highest families. It is recorded that the ladies of the Imperial Household in the eleventh century had bound feet.[9]

TECHNIQUE

In general, it may be stated that the technique used in producing bound feet is the reverse of that which is employed by the modern surgeon in correcting deformities such as those found in club feet. In either instance, the process requires a long course of bandaging, during which time the natural growth changes allow the feet to become reshaped according to their new confines. The process of binding the feet is started some time between the fourth and eighth years of life, usually about the sixth year, and is continued throughout the entire life of the individual. Should the parents be wealthy, the bandage may be of silk or of other costly material. Among the lower classes, strips of ordinary cotton cloth are employed, each measuring about three to five feet in length and from two to three inches in width. The number and size of the strips vary according to the size of the feet and the amount of tension which is exerted. Usually two to four bandages suffice for each foot. The first stage of the process begins with severe kneading and manipulation of the feet. The four outer toes are flexed upon the sole and are held in that position, the great toe being the only one allowed to project in its normal extended position. The metatarsals are pressed together as the bandages are applied. In spite of the pain after each kneading, the girl is forced to walk, in order to help reestablish the circulation. Following repeated manipulations and bandagings, over the course of approximately a year, the four outer toes are

* See Yu Cheng-hsieh, who based his conclusions on descriptions of shoes of Court ladies, which are found in the "History of Tang Dynasty" by Liu Hsu.

FIG. 1

Roentgenogram of a Chinese bound foot. Note the almost vertical position of the calcaneum and of the outer metatarsals.

successfully contracted against the sole, and the forefeet show marked narrowing. Then, during the next two or three years, the second stage of the manipulation and binding is vigorously carried out. The feet are kneaded and manipulated, so that they become flexed upon themselves through the mediotarsal joints. After each treatment, the feet are held in the new position with bandages applied in the figure-of-eight manner. Once the feet are reduced to the desired form and size, the various layers of bandage are sewed together and act as a substitute for a cast. This is changed at intervals of several months. At times, tightly fitting inelastic socks are worn for the same purpose.

Among the wealthy classes, technicians are called into the home to perform the foot-binding; among the poorer classes one of the members of the family does the work. By the age of eleven or twelve, the girl usually acquires the art of applying her own bandages. Finally, she begins to appreciate the social value and the beauty of her small feet, and she speaks proudly of them to her companions. Unless performed by gentle or experienced hands, the process is associated with great pain and discomfort to the girl. Among the poorer classes the mother may be inexperienced in bandaging and therefore there is great danger of complications, especially those which follow disturbances of the circulation. Later on in life, it is necessary to continue the bandaging indefinitely, since unbound feet become painful. If the bandages are removed, the feet lose their habitual support and strain of the ligaments and swelling of the soft tissues follow.

EFFECTS OF FOOT-BINDING

The anatomical changes to be observed in dissecting bound feet are quite distinct (Fig. 1). The outstanding changes are: (1) an approximation of the metatarsal heads to the posterior portion of the os calcis; (2) a change in the long axis of the os calcis from a horizontal plane to a vertical one, or even beyond the vertical so that an actual calcaneus deformity is produced; (3) a wedge-shaped deformity of the scaphoid, cuneiform, and cuboid bones; and (4) flexion deformities of the four outer toes. All bony and soft structures of the foot show marked atrophy. The intrinsic

muscles are usually reduced to small fibrous bands. As a consequence of the shortening and angulation of the foot, the height of the long arches is greatly increased and there is a furrow (Fig. 2), sometimes as deep as two inches, in the soft tissues of the sole of the foot, below the mediotarsal joint. There is extensive associated atrophy of all the muscles of the leg. The muscles of the thigh usually show a mild compensatory hypertrophy (Fig. 3), but this is probably more apparent than real. Since the os calcis lies in a vertical position, its long axis is continuous with that of the tibia and its posterior surface, where the tendo achillis is attached, becomes the inferior surface on which the weight of the body is sustained. If a complete calcaneus deformity is not present, the other points of support on the plantar surface of the foot are the distal end of the first metatarsal bone and the once extensor surface of the four outer toes. As a consequence of prolonged immobilization, the tarsal and tarsometatarsal joints show marked fibrous ankylosis. Movements of the ankle joint and of the great-toe joint are fairly well preserved.

FIG. 2

Plantar view of Chinese bound feet, showing characteristic deformity. Note the deep transverse crease beneath the mediotarsal joints, also the four outer toes which are completely flexed against the soles of the feet.

In an effort to determine any possible effects of the deformity upon the other parts of the skeleton, a complete roentgenographic study of all bones of the lower half of the body was made in six cases. All the findings were normal except for slight atrophy of the bones of the legs. The tibiae and fibulae were normal in density and in length, but slightly smaller than normal in circumference,—a change probably related or due to the associated atrophy of the muscles of the legs.

The ill effects of foot-binding may be classified under two headings: (1) those due to circulatory interference and infection of the tissues; and (2) those caused by weakening of the bones and ligaments. Almost every woman with bound feet suffers, at one time or another, from one of these conditions. During the process of binding, ulcers are often produced and

FIG. 3

Photograph of a Chinese woman with feet bound only to a moderate size. Note the atrophy of the feet and legs and the apparent hypertrophy of the thighs.

occasionally, in neglected cases with severe infection, the condition may go on to gangrene. The extent of impairment of walking is usually determined by the size of the feet. If the feet are bound to only a moderate size (from five to six inches in length) the woman usually gets along very well. If the feet are bound to a very small size (from three to four inches in length), walking and particularly running are greatly interfered with, the latter becoming practically impossible. (See Figure 4.) There is complete loss of elasticity of the gait, and therefore the spine is subjected to constant jarring upon any attempt to hurry. Occasionally one sees patients with static arch strain and also with corns and calluses, but the actual incidence of these conditions is probably no greater than that in normal feet. Apparently, binding does not predispose the feet to chronic arthritis or chronic bone diseases such as osteomyelitis or tuberculosis.

The evil effects of foot-binding have been realized by various of the past rulers of China. In the Manchu Dynasty (1680–1911 A.D.) an attempt to prohibit foot-binding was made by Kang Hsi. Chien Lung (1736–1790 A.D.) issued definite orders that all foot-binding among women must be stopped. These efforts did to some extent restrain this custom, but did not entirely control it. It was not until the overthrow of the recent Manchu Dynasty in 1911 that the governmental authorities were able to exert effective legislation against this practice. Fortunately, since that time, bound feet are rapidly disappearing from the eastern provinces of China. In many of the interior or western provinces where extreme conservatism still exists, and where the number of modern educated families is too small to exert any

FIG. 4

Photograph of a shoe worn on an unusually small bound foot.

influence upon the communities in which they live, foot-binding is still performed. Should China keep up its present stage of progress in education, the custom will probably become obsolete within the next two or three decades.

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THE EFFECT OF THE PERIOSTEUM ON FRACTURE FRAGMENTS*

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This paper is not concerned at all with the effect of the periosteum on the union of fractures or with its power to reproduce bone; it deals only with the mechanical effect of the periosteum either in assisting or in hindering proper reduction of a fractured bone.

Very little attention has been paid to the periosteum in this respect. Most of the difficulty in the reduction and the retention of fractures has been ascribed to the pull of the muscles on the bone fragments. Probably the muscles are the major factor in producing displacement, at least after the fracturing force has ceased to act, yet we have some experimental evidence that the periosteum may be a marked factor in preventing reduction. Ollier[2] in 1867 recognized the fact that the periosteum is not completely torn in fractures, but a portion remains intact, forming what he described as a periosteal bridge which he considered only from the viewpoint of the healing of the fracture.

Some ten years ago, the writer began a series of simple experiments which yielded some surprising results as to the mechanical effect of the periosteum on fresh fractures[1]. Since that time, other experiments have been made along the same line, and attempts have been made to apply the results clinically in order to check them in actual practice. The bones used have been obtained from one of the packing companies and fractured. In these bones the muscles and tendons were removed, but the periosteum was left intact. Various types of bones have been so studied,—beef and calf femora, humeri, tibiae, fibulae, and shank bones. These bones were all fresh,—that is, in each case the animal was alive less than twenty minutes before the bone was obtained. They were all from young or young adult animals. The bones were fractured in various ways and a wide variation in the types of fractures was noted. Also there was a wide variety of injuries to the periosteum.

Bone of course follows the general law of fracture of any other material,—that is, it bends with a compressive force on the concave side and with a stretching force on the convex, until the limit of elasticity is reached and fracture occurs. The fracture tends to be transverse, but variations occur, probably influenced by the grain of the bone and by the direction of the breaking force.

In general, transverse fractures produced the greatest effect as far as rupture of the periosteum was concerned. The periosteum was never torn completely, but a transverse tear usually was produced on the side opposite the fracturing force and close to the line of the fracture. This

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transverse tear involved from one-third to three-quarters of the circumference of the bone. The torn periosteum adjoining the fracture was not stripped from the bone, but the intact portion was always stripped to a considerable extent. This stripping was probably due mainly to the displacement of the fragments, which usually followed the actual fracture of the bone. When the bones were examined following the fracture, the feeling of elasticity in the intact strip of periosteum was quite striking. The elasticity was not great in extent, but it was definite. When the fragments of the bone were placed with the edges together under the intact periosteum and the bone was straightened, this elasticity of the periosteum caused the bone to snap straight, and the impact could easily be felt. This, of course, is the basis for the well-known fact that a fracture may often be more easily reduced by first increasing before correcting the deformity. When a relatively smooth transverse fracture with an overlapping deformity resulted, it was possible to stretch the periosteal bridge by hand traction exerted in the direction of the axis of the bone enough to secure good reduction. However, if there was even a moderate irregularity of the bone ends in an overlapping deformity, it was very difficult and frequently impossible to reduce the fracture by traction. The periosteum was not elastic enough to allow the irregularities to slip by and so the pull had a locking effect. To test the amount of pull necessary to overcome this, a stretching apparatus with a spring balance was made to determine the force exerted in overcoming this locking effect. In most cases it was found that the only force which was able to do this was one which would cause rupture of the periosteum. The force necessary for this was from fifty to sixty pounds. In cases where traction did not cause reduction the periosteum usually began to rupture at about this pressure. Rupture was not sudden, but consisted of a gradual slipping of the fibers.

When a long diagonal or comminuted fracture was produced, the periosteal injury was very different. Outwardly it was always much less in degree. The injury in these cases was never a transverse tear, but a longitudinal slit near the pointed end of one of the fragments. If there was much comminution of the bone there was frequently no injury to the periosteum unless there was a very marked displacement of one of the fragments. In either of these types, when the periosteum was opened, it was found widely stripped from the bone; often the entire circumference of the bone for the length of the fracture was denuded of periosteum. In other words, the periosteum remained as a practically intact tube. In this type of injury, traction on the ends of the bone gave the same feeling of elasticity noted before and good reduction was obtained unless it was prevented by the malposition of a comminuted fragment. The tube of periosteum, under traction, acted as a splint to maintain the reduction.

Spiral fractures were produced rather uncommonly, but they did occur even when the bone was broken by impact alone. In this type the fracture is really a long diagonal one with a rotational displacement of the

fragments. The periosteal injury in these cases was a combination of a tear and splitting. The torn portion was diagonal with a split extending longitudinally from the upper end of the tear. There was considerable stripping of the periosteum from the fragment which rotated. This type of fracture was not reduced at all by straight traction but was easily reduced by reversing the rotation of the fragment. However, the split edges of the periosteum practically always folded in, so that they were caught between the edges of the bone on reduction. This was the only type of fracture in which this regularly occurred.

This observation brings up the question as to inclusion of soft tissues between the bone ends. The untorn bridge of periosteum, which covers a half or a third of the circumference of the bone in transverse fractures, of course prevents any intrusion from that side. On the open side, however, it is a different matter, and muscle, fascia, or other tissue could easily be caught by the pinching action of the bone ends. The fate of any tissue so caught is problematic.

Mechanically the bone fragments joined by untorn periosteum form a toggle-joint by which the power is multiplied enormously, so that the pressure on any tissue caught between the ends may easily be subjected to pressures up to several hundred pounds. It is doubtful if any tissue in the body can long withstand any such pressure. This point may be worth further investigation.

Now as to the practical application of these observations,—we do not believe that the periosteum is the only structure at fault in resisting the reduction of fractures of the shafts of long bones, but we do believe that it must be taken into account more than it has been if fractures are to be treated on a thoroughly scientific basis.

The periosteum has enough tensile strength to be much more resistant to reduction by traction than we have believed. Furthermore, it does not tire as do muscles. Nevertheless, it can be torn by a powerful pull, and, when this is done, we have deprived ourselves of the valuable splinting action of the untorn strip of periosteal tissue, to say nothing of its regenerative action in the healing of the fracture.

Therefore, it seems logical to employ the gentler manipulative methods which most of us know, but which have penetrated the text-books to a surprisingly small extent. In most of the text-books with which the author is familiar, "strong traction" is the universal solvent for fractures. Also, with the increasing "gadgetization" of fracture treatment, the "strong traction" is becoming stronger and stronger. There is room for conservatism in pulling and hauling as well as in operative treatment.

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"SCIATICA" CAUSED BY INTERVERTEBRAL-DISC LESIONS

A Report of Forty Cases of Rupture of the Intervertebral Disc Occurring in the Low Lumbar Spine and Causing Pressure on the Cauda Equina

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The syndrome of low-back pain with radiation down the posterior thigh and the posterolateral calf has engaged the attention of the disciples of Aesculapius since the beginnings of the healing art. In more modern times the label of "sciatica" or "lumbago" is often attached by the patient to his disabling condition. "Radiculitis" and "peripheral neuritis" are terms which appeal strongly to the neurologist. The orthopaedic surgeon, on the other hand, has been able to popularize "sacro-iliac" and "lumbosacral joint" or "ligamentous strain". These and other similar diagnostic labels are essentially clinical concepts and have very little laboratory justification for their existence. There is no pathological specimen to examine, the ordinary roentgenogram is usually negative, and the rest of the routine laboratory work seems to shed little light on the situation.

Of the great numbers of patients who have low-back pain and "sciatica", there are a few that show objective pathology adequate to explain the symptoms. A well-marked spondylolisthesis, pelvic tumors (usually malignant) involving the lumbosacral plexus, tumors of the lower lumbar spine involving the cauda equina, all present an adequate cause for sciatica and can be demonstrated objectively at operation or at the autopsy table.

There is a group of cases in which the symptoms are due to pressure of a ruptured or herniated intervertebral disc on the cauda equina. It is only within recent years that intervertebral-disc lesions have been recognized as a cause of low-back pain with "sciatica", and the syndrome has as yet not been clearly described.

It is the purpose of this paper to review rather briefly the development of our knowledge of intervertebral-disc lesions, to report forty verified cases of intervertebral-disc lesions of the lower lumbar spine causing pressure on the cauda equina, to analyze the findings in these cases, and to draw such deductions and conclusions from the data as seem warranted.

HISTORICAL SURVEY

In 1896 Kocher reported a case of rupture of the intervertebral disc. A man, twenty-six years of age, fell from a height of 100 feet, landing in the standing position. He died of internal injuries within a short time. At autopsy he was found to have had a rupture of the disc between the first and second lumbar vertebrae without fracture of the vertebral bodies. The displaced intervertebral-disc tissue had apparently caused no cord damage.

In 1911, Middleton and Teacher reported the case of a man of thirty-eight who felt something "snap" in his back while he was lifting a heavy weight and was unable to straighten up. He had only local pain in his back until that night, when suddenly he felt as if his legs had gone to sleep and he could no longer move them. On physical examination he exhibited a complete flaccid paralysis of the lower extremities with absence of knee and ankle jerks, anaesthesia to the level of Poupart's ligament, and incontinence of urine and faeces. The patient died from urinary infection, and autopsy revealed a mass, one and five-tenths centimeters by five-tenths of a centimeter in size, anterior to the dura with its edges detached and free, at the level of the disc between the twelfth thoracic and the first lumbar vertebrae. There was no injury to the vertebral bodies. The mass was white and firm and "particularly resembled the central pulp of the intervertebral disc".

These two pathologically proved cases represent the first reports of rupture of the intervertebral disc so far as the author can ascertain.

In that same year (1911) Goldthwait reported the case of a patient suffering from a "right sacro-iliac strain", who developed a flaccid paralysis of the legs with disturbance of the genito-urinary system and the rectum, following an ether manipulation to "reduce" the subluxation. The paralysis partially disappeared after the patient had been placed in a good position, but it recurred the following night when the patient moved about unguardedly. Beyond the signs of paraplegia, nothing was found on physical examination except slight tenderness at the lumbosacral junction. A laminectomy was performed by Cushing, who found no lesion of the cauda equina except for "narrowing of the osseous canal at the lumbosacral junction". The patient made a slow partial recovery following the operation. In a detailed discussion of the case, Goldthwait reviewed the various possible causes of the paraplegia. He dismissed tumor, hemorrhage, and spondylolisthesis as possible factors and *concluded* that posterior displacement of the lumbosacral intervertebral disc with pressure on the cauda equina was the logical explanation. He suggested that other cases of paraplegia, lumbago, and "sciatica" might be due to pressure on nerve roots from a displaced intervertebral disc.

Neurological surgeons have recognized for many years that there is a small cartilaginous extradural tumor arising from the intervertebral disc which may cause cord or cauda-equina pressure. In 1923, Ott and Adson reported two such cases and called them fibrochondromata. Again, in 1925, Adson reported an additional case, calling it a cervical extradural ventral chondroma. Veraguth reported a similar case in 1928, calling it a myxochondroma. Stookey described seven cases in detail and discussed the neurological findings. All of his cases were in the cervical region. Elsberg in 1931 reported fifteen such cases in which operations had been performed. He described the symptomatology and the physical and laboratory findings in detail. Histological examination showed the material removed at operation to be practically identical with normal disc

tissue. He concluded that the tumor was benign and that "chondroma" or "ecchondrosis" best described it. Bucy, Bailey and Bucy, and Mixter have reported similar cases.

In 1929 Dandy reported two cases of "loose cartilage" which was detached from the intervertebral disc and caused pressure on the spinal cord. He considered the condition similar to osteochondritis dissecans and felt that it was traumatic in origin in each case.

Von Péchy, Klinge, and Kortzeborn, familiar with Schmorl's work, have each reported a case of Schmorl's nodule (*Knorpelknötchen*) on the posterior aspect of an intervertebral disc, causing spinal-cord pressure.

Three cases of a fibroma or of a fibrocartilaginous nodule arising from an intervertebral disc and causing cauda-equina pressure are reported in the French literature (two by Alajouanine and Petit-Dutaillis, and one by Crouzon, Petit-Dutaillis, and Christophe). The etiology was considered to be trauma.

Galland, and Calvé and Galland have described two instances of paraplegia in cases with severe thoracic kyphosis which they attributed to "retropulsion" of the nucleus pulposus.

In 1934, Peet and Echols reported two cases of "herniation of the nucleus pulposus", one of which was cervical, the other lumbar. In both cases there were signs of pressure on the spinal cord, which was relieved by operation.

In the same year, Mixter and the author of this paper reported nineteen proved cases of rupture of the intervertebral disc with involvement

TABLE I

TERMINOLOGY DESCRIPTIVE OF RUPTURE OF THE INTERVERTEBRAL DISC

Authors	Terminology
Bailey and Bucy Elsberg Stookey Adson and Ott	Intervertebral-disc chondroma Ventral extradural chondroma Ecchondrosis
Veraguth	Myxochondroma
Alajouanine and Petit-Dutaillis Crouzon, Petit-Dutaillis, and Christophe	Fibroma Fibrochondroma
Klinge Kortzeborn von Péchy	Schmorl's nodule (*Knorpelknötchen*)
Mixter and Ayer Mixter and Barr Peet and Echols	Rupture or herniation of the intervertebral disc Herniation of the nucleus pulposus Prolapse of the nucleus pulposus
Dandy	Loose cartilage from the intervertebral disc

of the spinal canal. They called attention to the similarity of chondromata to these lesions. They also noted that in the lumbar region the pressure on one or more roots of the cauda equina caused symptoms very similar to those of low-back strain (sacro-iliac and lumbosacral). Mixter and Ayer, a year later, reported thirty-four cases of "herniation or rupture of the intervertebral disc". The nineteen cases reported by Mixter and Barr were included in this group.

The author believes that the writers mentioned were all describing the same pathological entity which is referred to in this paper as *rupture of the intervertebral disc.*

At the Massachusetts General Hospital, from 1927 to November 1936, fifty-three cases of rupture of the intervertebral disc have been verified by operative removal and histological examination of the material. In nine cases, the lesion was in the cervical region; in three, in the thoracic region; and in forty, in the lumbar region. In the remaining case, the lesion arose from the sacrum, presumably from the remnants of the disc between the first and second sacral segments.

Schmorl and his pupil Andrae noted that in 15 per cent. of spines routinely examined at autopsy there were small nodules (*Knorpelknötchen*) protruding posteriorly from the intervertebral disc into the spinal canal. They occurred more frequently in females (18.7 per cent.) than in males (11.5 per cent.). The nodules were small and Andrae concluded that they ordinarily did not produce clinical symptoms from cord pressure. He discussed trauma, degenerative changes in the annulus fibrosus, and developmental anomalies as possible etiological factors.

Mauric in 1933 published a monograph on the intervertebral disc in which he reviewed the literature to date. In particular he laid stress on the clinical importance of the cases of spinal-cord or cauda-equina pressure from posterior herniation of the disc.

CLINICAL FINDINGS

The signs and symptoms of rupture of an intervertebral disc depend upon the location of the lesion. Cervical and thoracic lesions are excluded from this discussion. *Lesions in the lumbar region produce a characteristic clinical syndrome.*

Forty cases of rupture of an intervertebral disc in the lumbar region, causing pressure on one or more roots of the cauda equina, have been verified by operation at the Massachusetts General Hospital in the period from 1927 to November 1936, and their records have been studied in preparing the data for this paper. (See Tables II, III, IV, and V.)

The fact that twenty cases have been operated upon and verified in a single ten-month period in a general hospital of moderate size suggests that this entity is not particularly rare and that many cases have been overlooked or wrongly diagnosed in the past.

It is interesting to note that in 65 per cent. of the cases the lesion was in the disc between the fourth and fifth lumbar vertebrae and in only 30

TABLE II

INCIDENCE

Year	Verified Cases
1927	1
1930	1
1931	1
1932	5
1933	1
1934	5
1935	6
1936 (to Nov. 1)	20
Total (1927 to 1936)	40

TABLE III

LOCATION OF LESION

Disc Between	Cases
Second and third lumbar	1
Third and fourth lumbar	1
Fourth and fifth lumbar	26
Fifth lumbar and first sacral	12
Total	40

TABLE IV

AGE INCIDENCE

	Years
Youngest	20
Oldest	58
Average	37
Median	36

TABLE V

SEX INCIDENCE

	Cases	Per Cent.
Female	5	12.5
Male	35	87.5
Total	40	100.0

per cent. in the lumbosacral disc. The explanation for this is not clear.

The high incidence of this entity in males in this series of cases is not unique. Of seventy-seven previously reported cases in the literature, sixty-seven were males and ten were females. This corresponds roughly to the incidence of "sacro-iliac" and "lumbosacral" strain with sciatica in males and females and suggests strongly that trauma is a major etiological factor.

Trauma

In thirty-one (77.5 per cent.) of the cases, there was elicited a history of trauma which the patient felt was a causative factor. In twenty-one instances the disability followed *immediately* after the trauma and in ten there was a latent period before the onset of symptoms.

The type of trauma was extremely varied; the most common was lifting a heavy weight. Falls from a height and twisting strains were much less frequent. These facts suggest that abnormal pressure on a disc can produce a sudden rupture of the annulus fibrosus with immediate posterior prolapse of sufficent disc tissue to produce pressure on the cauda equina. It is possible that in other cases there had been in the past some unremembered trauma which produced a slight tear or weakening of the annulus fibrosus. The ordinary stresses of weight-bearing over a period of time were then sufficient to produce a slowly enlarging herniation or prolapse of disc tissue. In their case reports, Kocher, Middleton and Teacher, Dandy, and Alajouanine and Petit-Dutaillis have all emphasized the element of trauma in the production of the lesion. Experimental evidence is scanty. Ribbert was able to produce Virchow's tumor (ecchondrosis physaliphora) in rabbits by puncturing the intervertebral disc. Schmorl stated that Roux was able to rupture intervertebral discs in excised spines by compressing them hydraulically. Petter found that the average expansile force of each intervertebral disc was thirty and two-tenths pounds per square inch.

The author of this paper has tested the effect of pressure on discs excised at autopsy in the following manner. A portion of the lumbar spine, consisting of two vertebrae, was excised by passing a knife through the intervertebral disc above and below and removing the muscles by sharp dissection. The cartilage plates were left intact on either end. The vertebrae were then placed in a vise and pressure was gradually applied to the vertebrae and the intact disc between them by tightening the jaws of the vise on the cartilage plates on either end. As the pressure was increased, the height of the disc decreased and it bulged symmetrically at its periphery. When the pressure was released, the disc resumed its normal shape. This could be repeated *ad libitum*, demonstrating the usual elastic behavior and function of the disc. If the pressure was increased beyond a certain point, there ensued a sudden rupture of the disc at its periphery with escape of a portion of the disc tissue (nuclear material) through the longitudinal ligament. The disc then lost its elasticity and failed to return to its normal shape when the pressure was released.

This rupture of the annulus fibrosus seemed to occur at any point in its periphery. If the annulus fibrosus was punctured with a needle or with the tip of a scalpel, the rupture invariably occurred at that point. It would seem that the disc is composed of an incompressible semifluid center (nucleus pulposus) contained in a highly elastic envelope which is the annulus fibrosus. If the tensile strength of the annulus fibrosus is exceeded, rupture occurs and the whole unit loses its function. A rich field for investigation is here opened. Further work is necessary to determine the pressure required to produce disc rupture, the usual sites of rupture, etc.

Pease has reported twelve instances of injury to intervertebral discs, as shown by narrowing of the intervertebral space and sclerosis of vertebral bodies, following lumbar puncture, due presumably to trauma which occurred because the needle was introduced too far. In none of his cases was there evidence of root or spinal-cord pressure.

Duration of Symptoms

The duration of symptoms from onset to operation varied widely. The shortest period was six weeks; the longest, twenty-two years; and the average, thirty-four months. Twenty-four of the patients (60 per cent.) were suffering from the original disabling attack when operated upon. Sixteen patients (40 per cent.) had had remissions and recurrences of symptoms. *A priori*, one would suppose that a herniation of the intervertebral-disc tissue, sufficient to produce nerve-root pressure, would remain as a constant etiological factor until removed at operation and that it would be impossible for a patient to recover and remain symptom-free under conservative treatment. However, in many of these cases the patients had recurring attacks with remissions. The symptoms usually became more disabling with each attack. It is interesting to speculate as to what happens in these cases with recurrent symptoms. Does the prolapsed tissue shrink in size or return to normal position with rest, etc., or does the nerve root involved alter its position by slipping to one side? We certainly have no definite knowledge concerning these matters. Other authors, particularly Elsberg and Stookey, have noted that there may be remissions and relapses in the symptoms.

Analysis of Symptoms

Pain was the usual chief complaint and was the major presenting symptom in every case. The painful areas in order of frequency were: (1) posterior and lateral thigh, 100 per cent.; (2) posterolateral calf, 90 per cent.; (3) lumbosacral region, 70 per cent.; (4) gluteal and sacro-iliac regions, 65 per cent.; (5) lateral border of foot, 5 per cent. Other areas, such as the sole of the foot, the great toe, etc., were complained of in single instances.

The pain in the lumbosacral region is perhaps best explained by the local irritation of the injured disc. According to Schmorl, the disc itself has no nerve supply, but the posterior spinal ligament has a sensory supply

and thus strain or pressure on it from the prolapsed disc would presumably be painful.

The pain in the thigh and the leg was of the type commonly referred to as "sciatic". It was usually described as a deep-seated burning or shooting pain, often excruciating in intensity. The pain varied greatly in intensity and was often aggravated by coughing, sneezing, and change in position. The position of least discomfort varied greatly. Bed rest usually brought some relief, but some patients were more comfortable standing or sitting. At operation the ruptured disc fragment was found to press on only *one* root of the cauda equina in over half of the cases. Hampton and Robinson have demonstrated that, if the rupture is in the disc between the fourth and fifth lumbar vertebrae, the root of the fifth lumbar is always involved, whereas, if the rupture is in the lumbosacral disc, the root of the first sacral is the first one pressed upon. The effect of pressure on only one of the roots which go to make up the lumbosacral plexus can thus be demonstrated. In no instance of pressure on one root were there objective sensory changes present. This serves to corroborate Foerster's observation that section of a single nerve root produced little or no sensory change because of the marked overlap in the sensory supply of the skin.

The areas of referred pain were identical, no matter whether the fifth lumbar or the first sacral roots were involved. One might suppose that pain due to irritation of a nerve root would be referred to the peripheral dermatome supplied by that root. This is not true, in so far as we are able to determine. Every patient complained of pain in the posterior thigh (second sacral dermatome). A number of patients with pain in the lateral calf (fifth lumbar dermatome) were found at operation to have a lesion at the lumbosacral disc below the point of exit of the root of the fifth lumbar which was obviously not impinged upon. A careful study of these cases has convinced the author that the referred pain has no obvious relationship to the sensory dermatomes and that the location of the lesion cannot be inferred from the distribution of the areas of referred pain.

In thirty-four instances the referred pain was strictly unilateral. In six there was radiation of pain down both legs.

Although the presenting symptom in each case was pain, a certain number of patients complained of numbness, muscle weakness, cramps in the calves of the legs, and urinary and faecal incontinence. These will be discussed more fully.

Previous Treatment

These patients, almost without exception, had had prolonged orthopaedic treatment of one type or another. Bed rest, heat, adhesive strapping, belts, corsets, back braces had all been used many times, often with partial or with complete temporary relief.

One patient had had an ether manipulation to reduce a "sacro-iliac subluxation". The result of the manipulation was a complete paraplegia,

due to pressure on the cauda equina from a large rupture of an intervertebral disc. Two other cases of paraplegia following ether manipulation are known to the author, but are not included in this series. This seems to indicate that *manipulations which place severe strain on the lumbar spine are hazardous* and should be abandoned.

One patient in this series had had a sacro-iliac fusion, and two patients had had division of the iliotibial band (Ober fasciotomy) for the relief of low-back "sacro-iliac" strain. The sacro-iliac fusion gave no relief from symptoms. One of the patients upon whom a fasciotomy was done was completely relieved for one year; the other patient was relieved for two months. Both patients then had very disabling recurrences of symptoms and the correct diagnosis was finally made.

Signs

The position in which the lumbar spine was held varied somewhat. In twenty-six cases there was a *list* of the lumbar spine (sciatic scoliosis). The list was away from the site of the lesion (contralateral) in thirteen cases, toward it (homolateral) in eleven cases, and in one case the lumbar spine showed a fixed list, whereas the lesion was in the midline. There was one case of alternating scoliosis in which the list shifted from one side to the other on several occasions.

In twenty-seven cases there was present a lumbar *kyphos* in the region of the spinous processes of the third, fourth, and fifth lumbar vertebrae. This was a fixed deformity in most cases and could not be altered by active or passive attempts to hyperextend the spine. The kyphos represented fixation by muscle spasm and disappeared postoperatively in every case save one after the nerve-root pressure was relieved. In that one case a spine fusion had been done, thus producing a permanent fixed deformity.

In every case in which the record contains specific data *back motions* have been restricted markedly. In some instances all motion of the lumbar spine was abolished both in the standing and in the lying positions. In others, motion was more free in the sitting or in the lying position than in the standing position.

In thirty-six cases in which the straight-leg raising test was made, motion was restricted. It was always more restricted on the side of greater pain. In eleven cases the unaffected side showed no restriction in motion.

Tenderness to pressure was present in the midline at the level of the lesion in fifteen cases, over the posterior sacro-iliac ligaments in fourteen cases, and at the sacrosciatic notch in ten cases. In several instances there were no data as to points of tenderness.

Reflexes

The knee jerks were normal in every instance. The ankle jerk was absent bilaterally in six cases, unilaterally in fourteen cases, normal in nineteen cases, and not stated in one,—*i. e.*, 50 per cent. of the cases showed absent ankle jerk. Those cases in which the ankle jerk was un-

affected were in general milder and of shorter duration than those in which it was absent. The Babinski response was either plantar or absent in all cases but one in which it was equivocal. There was an unsustained ankle clonus in one case.

In three cases there was urinary and faecal incontinence amounting to complete loss of sphincter control. In two cases there was dribbling of urine and in one instance, other than the three cases of paraplegia, loss of sexual potency was noted.

Atrophy with some degree of muscle weakness was noted in eight cases. In three of these the weakness was generalized and involved both legs. In one instance one foot was essentially flail. In one case the gastrocnemius was the only muscle involved.

Two patients showed fibrillary twitching and cramps of the calf muscles.

Sensory Changes

Sensory changes were present in seventeen cases. In three of them there was saddle anaesthesia. The others showed hypaesthesia or anaesthesia of varying extent. The involved areas were similar to the areas of referred pain,—*i. e.*, posterior thigh, lateral calf, lateral border of the foot.

Roentgenographic Examination

The usual flat films (stereo-anteroposterior and lateral) of the lumbosacral region revealed the changes shown in Table VI.

From this experience it would seem that the usual roentgenographic examination gives no information concerning the location of the lesion in

TABLE VI

CHANGES IN LUMBOSACRAL REGION AS DEMONSTRATED ROENTGENOGRAPHICALLY

Changes	Group Cases	Group Per Cent.	Total Cases	Total Per Cent.
I. Hypertrophic changes, spur formation, increased density of the vertebral margins:				
A. Local at the site of the lesion	13	32.5		
B. General	3	7.5	16	40.0
C. No changes present	23	57.5		
D. Roentgenograms not available	1	2.5	24	60.0
II. Narrowing of the intervertebral disc:				
A. Very marked	3	7.5		
B. Marked	7	17.5		
C. Slight	5	12.5	15	37.5
D. No narrowing	25	62.5	25	62.5
III. Concave vertebral bodies (expansion of the intervertebral disc)	5	12.5	5	12.5

one-half of the cases. In those instances where the roentgenogram shows narrowing of an intervertebral disc and (or) local hypertrophic changes the information might be considered suggestive. It certainly is not *conclusive* evidence of nerve pressure from a prolapsed disc as the routine roentgenographic examination of the spine reveals such changes in cases with no symptoms whatever.

Lipiodol Examination

Lipiodol examination was carried out in thirty-nine of the forty cases. The results are given in Table VII.

TABLE VII

RESULTS OF LIPIODOL EXAMINATION

	Cases
Total block demonstrated	5
Partial block or filling defect	30
Question of filling defect	1
Negative examination	3
Total	39

Of the thirty-six cases with positive lipiodol findings, the location of the lesion was verified at operation in each instance. In other words, there were no "false positive" results. The three patients in whom lipiodol examination gave negative results were found at operation to have small disc lesions so far lateral in the intervertebral foramen that only one nerve root was involved. They were examined with small amounts of lipiodol and the lesions could not have produced filling defects in the lipiodol column. *Lipiodol examination was 90 per cent. accurate in localization of the level of the lesion in this series.* In twenty-five cases the roentgenologist made a diagnosis of "rupture of the intervertebral disc" from the roentgenographic findings alone.

The technique of lipiodol examination has been reported in detail by Hampton and Robinson. It is important to inject a large enough quantity of lipiodol to fill the lower dural sac, thus permitting examination of the lower two intervertebral discs in the standing position. We now use from four and five-tenths to five cubic centimeters of the iodized oil. Careful fluoroscopic examination is made and "spot films" of any block or filling defect are taken. The anteroposterior or slightly oblique view has usually demonstrated the lesion better than the lateral view.

No untoward results from the use of lipiodol occurred in any of our cases. Arachnoiditis has been reported by other writers. In each case at the time of operation as much lipiodol as possible was removed from the spinal fluid.

In thirteen of the cases postoperative roentgenograms of the lumbar

spine were obtained. The longest period of time after operation was five years; the shortest, five weeks. The results of this examination are discussed later in the end-result study.

Lumbar Puncture

Lumbar puncture was performed in each case. Manometric test revealed evidence of a dynamic block above the level of the needle in four cases (10 per cent.). In the other thirty-six cases the dynamics were normal. The total protein has been above 45 milligrams per 100 cubic centimeters in thirty-five of the cases. The others had total proteins of 27, 33, 35, 40, and 41 milligrams per 100 cubic centimeters respectively.

Until the past year, a total protein below 40 milligrams per 100 cubic centimeters was considered indicative of no pathology in the cauda equina and, therefore, in such cases lipiodol examination was not done. At the present time, if the patient's symptoms and clinical examination are consistent and he is unrelieved by conservative therapy, we do not hesitate to do a lipiodol examination even when the total protein is within normal limits (20 to 40 milligrams per 100 cubic centimeters). The fact that five cases of proved disc lesions have been found, each with spinal-fluid total protein within normal limits, is disturbing. *We now know that a negative lumbar puncture does not rule out rupture of the intervertebral disc.*

In one or two instances the spinal fluid was xanthochromic. The white blood count and the red blood count revealed a very few cells in some instances. There was no case with a significant increase in the cell content of the fluid. The gold-sol and Wassermann tests were negative in each instance. The chloride and sugar content of the spinal fluid was not altered appreciably in any instance.

OPERATIVE TECHNIQUE AND FINDINGS

In this series of cases, with one exception, the operations were performed on the Neurosurgical Service and most of the cases were operated upon by Dr. W. J. Mixter, the Chief of the Neurosurgical Service. The operative technique has been described by Elsberg, Stookey, and Mixter. A laminectomy is done in which the spinous processes and laminae of from two to four vertebrae are removed as seems indicated. If the lesion has been accurately localized and lies on one side, a hemilaminectomy may be done. In those instances where the lesion is small and lies far laterally in the intervertebral foramen, it is usually necessary to remove one articular facet and a portion of the pedicle before the lesion can be demonstrated. After the dura has been thoroughly exposed, it is palpated carefully. Usually the intervertebral-disc lesion can be felt through both layers of the dura, appearing as a small nodule over which the finger rides. If the lesion lies laterally and can be felt without opening the dura, it may be possible to remove it extradurally. It usually was necessary to open the dura in order to gain accurate knowledge as to the position and the size of the lesion, and in most instances it was necessary to remove the lesion trans-

durally by a second vertical incision through the anterior dura after carefully separating and retracting the fibers of the cauda equina. Before the dura is opened, the patient's head is raised slightly, allowing the lipiodol to fall into the sacral cul-de-sac. After the dura has been opened, cotton pledgets are carefully packed in the upper end of the incision and the lipiodol is removed with the suction apparatus. In this way all but a very small portion of the lipiodol is removed, and can no longer be a potential source of arachnoiditis. After the lesion is located, examination of the nerve root or roots impinged upon shows that they are usually flattened and the sheaths are injected, giving objective evidence of the irritation which has occurred from the pressure of the protruding mass. After exposure of the lesion, which appears as a small rounded eminence, usually varying in size from that of a pea to that of a hickory nut, the dura is incised over it. A pair of Allis forceps is introduced and the mass is grasped firmly. It can usually be removed *in toto* without sharp dissection. The mass has an appearance similar to wet, rolled-up blotting paper, usually grayish or pinkish in color. Occasionally it is necessary to sever one or two of its attachments to the intervertebral disc with scissors or scalpel. If a probe is introduced into the spot from which the mass was removed, a hole can usually be demonstrated which runs down into the depths of the intervertebral disc. In several of these cases such a sinus was demonstrated and its connection with the nucleus pulposus was shown by introducing a silver clip into the area; its location was then demonstrated by postoperative anteroposterior and lateral roentgenograms. The defect in the anterior dura is not repaired. The posterior dural incision is sutured with black silk and the operative incision is closed in the usual fashion.

The question of whether a spinal fusion should be performed following the laminectomy is of great importance. On theoretical grounds it would seem that a spinal fusion might help to prevent further posterior displacement of intervertebral-disc tissue and recurrence of symptoms. In one of the cases in which spinal fusion was performed the patient had at the time of operation a fixed kyphoscoliosis. Fusion was rapid and complete and the patient's spine has remained in the deformed position. It would seem, then, that if fusion is performed, it should *not* be done in the presence of altered spinal mechanics such as scoliosis or kyphosis. If the laminectomy has been so extensive as to remove one or more of the articular facets, it would seem advisable to perform a spinal fusion to insure sufficient stability for the spine. This might be done either at the time of the laminectomy or at a second operation. In twelve of the forty cases in this series a spinal fusion was done at the same time as the laminectomy.

The postoperative course in these cases has as a rule been quite uneventful. Occasionally catheterization has been necessary for a few days after operation. In two cases there was a definite increase in the amount of motor weakness, presumably due to operative trauma. The immediate and complete postoperative relief from the sciatic pain is

dramatic and strongly suggests that the etiological factor has been corrected!

HISTOLOGY

The microscopic examination of the excised material reveals that it is normal disc tissue and not "chondroma". There is considerable variation in the histological appearance, depending on which portion of the disc was removed and on the age of the subject. If it is the annular portion, dense fibrous tissue with an occasional cartilage cell predominates. If it is chiefly nucleus pulposus, there is a loose granular reticulum, the spaces of which are filled with mucoid material and with occasional poorly differentiated groups of cells which may be remnants of the notochordal cells or of the fibrocartilaginous cells. In some instances there may be present bits of bone or a small part of the posterior longitudinal ligament.

It is by the careful comparison of this material with sections of normal intervertebral discs that we have reached the conclusion that the terms "chondroma", "enchondroma", etc., are not appropriate. The material is simply misplaced intervertebral-disc tissue.

END-RESULT STUDY

Every one of these cases has been followed long enough after operation to know the immediate result, although not enough time has elapsed in some instances to allow us to ascertain the final result.

Two patients have died at the time of completion of this study (December 1936). One died of uraemia following a complete paraplegia with urinary incontinence, due to the disc lesion which was present preoperatively, and death may be appropriately considered as due to rupture of the intervertebral disc. The second patient died, presumably of pneumonia, well over a year after operation. The disc rupture and operation had no apparent bearing on his death, as he had made almost a complete recovery when last seen.

Relief from pain was striking. Twenty-nine patients were completely relieved from pain; nine had only slight residual discomfort. In only one instance was relief from discomfort and pain not essentially complete, and in this instance there was evidence at operation of other pathology,—*i. e.*, arachnoiditis, sufficient to cause continuing symptoms.

Eight patients had no residual disability and were able to resume all their pre-illness activities. Nine patients were restricted to lighter work than they had had preoperatively, but they were otherwise well. Two patients had disabling motor weakness or paralysis. The remaining patients, operated upon within the past year, have not been allowed to resume full physical activity as yet. There were no instances of muscle weakness or paralysis occurring after operation in these recent cases.

The fate of the involved intervertebral disc is interesting and important. In thirteen cases postoperative roentgenograms have been obtained and compared with the preoperative ones. In four there was definite increased narrowing of the intervertebral space and in one of them there

were present increased local hypertrophic changes. This finding was not unexpected, for the disc must have been weakened by the original rupture of the annulus fibrosus and the operative removal of the prolapsed tissue leaves an unrepaired hiatus in the disc which has been proved in several cases to extend into the region of the nucleus pulposus. What is to prevent further extrusion of disc tissue with recurrence of root pressure? The history of the fatal case suggests that this actually occurred. It seems reasonable to assume that as time elapses more of these cases will show degenerative changes (grinding up) of the affected disc and possibly there may be some with actual recurrence of symptoms. The one therapeutic defense against this event would seem to be the thorough removal of the nuclear material at the time of the operation plus spinal fusion of the affected area.

FIG. 1

Photograph of a portion of a spine removed at autopsy. Pedicles have been cut near the vertebral bodies, thus removing the neural arch and the spinal cord. A posterior prolapse, measuring one centimeter in diameter, is present. It occasioned no symptoms, but it is quite similar to those which do cause nerve-root pressure.

CASE REPORT

The following case abstract illustrates some of the points discussed in the paper. The case is the most recent one of the forty here reported.

V. C. (M. G. H. No. 356804), female, aged twenty-five, is an unmarried clerk. Her family history and past history are irrelevant. The patient was first seen in the emergency ward of the Massachusetts General Hospital on October 10, 1936. Her chief complaint was pain in the left posterior thigh and calf. Three years previously the patient had had a sudden attack of pain in the left sacro-iliac region following vigorous exercises to reduce her weight. Osteopathic manipulation and rest in bed had relieved the symp-

toms. During the previous three years she had had three similar attacks, each beginning with some minor twist or strain of the low back. Each time the symptoms had been relieved by osteopathic manipulation, adhesive strapping, and rest in bed. In the interval between attacks she had felt perfectly well.

The last attack began in similar fashion two weeks previous to admission, but was much more severe and she had obtained no relief even from rest in bed. There was mild discomfort across the lumbosacral region and over the left sacro-iliac region. Intense pain radiated down the left posterior thigh and posterior lateral calf to the external malleolus. Coughing, sneezing, and twisting motions caused exacerbation of the pain.

On examination the patient stood with most of her weight borne on the right leg. The lumbar spine was held rigidly and the normal lordosis was obliterated. There was a fixed list to the left (homolateral scoliosis). In the standing position, all motions of the lumbar spine were markedly restricted by pain and muscle spasm. In the sitting position, motions were a little more free but were still markedly restricted. There was tenderness in the midline over the spinous processes of the fourth and fifth lumbar vertebrae. There was no tenderness elsewhere. Straight-leg raising was limited by hamstring spasm to 40 degrees on the left and to 60 degrees on the right.

FIG. 2

Lateral view of the lumbar spine of patient V. C. Note the slight narrowing of the interspace of the fourth and fifth lumbar vertebrae, and the slight spur formation on the anterior margins of the fourth and fifth vertebral bodies.

There were no sensory changes. All reflexes, including the ankle jerks, were equal and active.

Lumbar puncture, done at the interspace of the fourth and fifth lumbar vertebrae, showed no alteration in dynamics. The total protein was 46 milligrams per 100 cubic centimeters.

Five cubic centimeters of lipiodol was injected into the subarachnoid space. On fluoroscopy, a characteristic filling defect was found at the level of the disc between the fourth and fifth lumbar vertebrae on the left side, which was interpreted as a ruptured disc.

At operation on October 17, 1936, the dura was exposed through a left hemilaminectomy. The laminae of the third, fourth, and fifth lumbar vertebrae were removed, together with the articular facet between the fourth and fifth vertebrae. On palpation of the dura, a mass about one centimeter in diameter could be felt, arising anterior and to the left of the dura at the level of the disc between the fourth and fifth lumbar vertebrae. It encroached upon but did not completely occlude the subarachnoid space. When the dura was opened, the left fifth lumbar root was seen to ride over the mass. The root showed evidence of irritation, as it was covered with a fine network of injected blood vessels. The dura and cauda equina were retracted toward the midline, exposing the mass extradurally. On incision of the posterior longitudinal ligament, a ragged detached fragment of the intervertebral-disc tissue was easily extracted. It measured about one by one by five-tenths of a centimeter and resembled in the gross a fragment of fibrocartilage. All the pressure on the involved root was relieved by this manoeuver. The lipiodol was removed by suction. The dura was closed with silk. A Hibbs type of fusion was then done on the right side from the third lumbar vertebra to the sacrum inclusive. The wound was closed with silk, and the patient was placed in plaster shells which had been made before the operation.

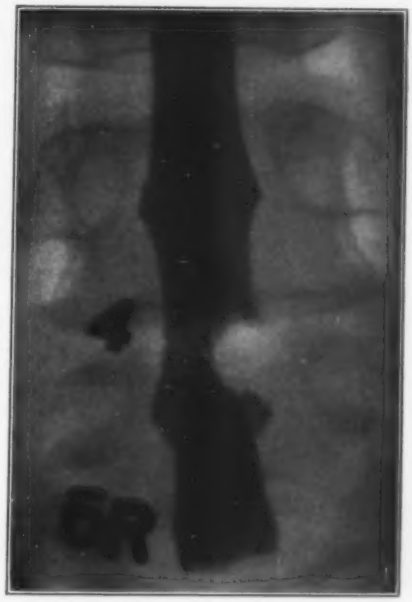

FIG. 3

Anteroposterior "spot film" of the low lumbar spine of patient V. C. after injection of lipiodol. Note the filling defect on the left side at the level of the disc between the fourth and fifth lumbar vertebrae. This defect remained constant on repeated examinations. The rupture was found at operation at exactly this location, but was not quite as large as the x-ray seemed to indicate.

Postoperative convalescence was uneventful. The patient had no sciatic pain after the operation. She was discharged from the Hospital on November 10, 1936, free from all symptoms. The final result cannot be determined as yet as insufficient time has elapsed since the operation.

The histological section of the removed tissue was reported to be from a normal intervertebral disc.

SUMMARY AND CONCLUSIONS

A review of the literature reveals that much is known of the normal anatomy and physiology of the intervertebral disc and that, chiefly due to Schmorl's work, the pathological changes which may occur are fairly well elucidated. The entity of posterior prolapse into the spinal canal is of great clinical significance, as it may cause disability and even death from pressure on the cord or on the cauda equina. The lesion known as "chondroma" or "ecchondrosis" of the intervertebral disc is apparently the same as the posterior prolapses.

The cases in which the lesion is in the low lumbar spine may show symptoms and signs indistinguishable from those of sacro-iliac or lumbosacral strain and so are seen primarily by orthopaedic surgeons.

Unless the specialists in this field are aware of the entity and take the proper steps to arrive at the correct diagnosis, useless orthopaedic treatment will be instituted. A careful neurological examination, in addition to the orthopaedic examination, is indicated in every case of "low-back strain". If the symptoms remain intractible after adequate conservative treatment, lumbar puncture should be performed and the total protein content of the spinal fluid should be determined. If it is over 50 milligrams per 100 cubic centimeters, the evidence is in favor of an intraspinal lesion rather than mechanical joint or ligamentous strain, and, therefore, sacro-iliac or lumbosacral fusion is contra-indicated until cord or root pressure is ruled out by careful lipiodol roentgenographic examination. Even if the total protein is within so called normal limits, there may be present a ruptured disc which is responsible for the patient's symptoms.

Forty cases of proved rupture of the intervertebral disc into the lumbar spinal canal with involvement of one or more roots of the cauda equina by direct pressure have been reported in this paper. Twelve were in the lumbosacral disc, twenty-six in the disc between the fourth and fifth lumbar vertebrae, one between the second and third lumbar, and one between the third and fourth lumbar.

There were thirty-five males and five females. The average age was thirty-seven years.

A history of trauma was present in 77.5 per cent. of the cases.

Pain was the major presenting symptom. Its character was that of the familiar "sciatica", always radiating down the posterior thigh and usually the posterolateral calf.

Orthopaedic examination revealed the classical signs of low-back strain,—muscle spasm, list, limitation of motion, limitation of straight-leg raising, tender areas, etc. Fixed lumbar kyphosis or an abnormally flat back was present in over half of the cases.

Neurological examination revealed definite peripheral sensory changes in seventeen cases. There was an absent ankle jerk in 50 per cent. of the cases. Muscle weakness, paralysis, cramps, and loss of urinary and rectal control were less frequent, but they occurred.

Lumbar puncture revealed an elevated total protein in all but five cases. The average was 60 to 100 milligrams per 100 cubic centimeters.

Roentgenograms showed local hypertrophic changes or disc narrowing in less than half the cases.

Lipiodol examination localized the lesion in thirty-six of the forty cases.

The end-result study showed one death due to the lesion (paraplegia). There was essentially complete relief from pain in all cases but one. In that one the continued pain seems to be due to other pathology.

Sufficient time has not elapsed to permit determination of the amount of permanent disability following the operative removal of a ruptured disc. Our experience indicates that the back is stronger if fusion is combined with the laminectomy.

There seems to be no doubt that a clinical entity with a proved

pathological etiology is being removed from the vague classification of lumbosacral and sacro-iliac strains. It is not excessively rare and should be thought of in every case of back strain and "sciatica".

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LESIONS OF THE LUMBOSACRAL SPINE *

PART I. ACUTE TRAUMATIC DESTRUCTION OF THE LUMBOSACRAL INTERVERTEBRAL DISC **

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The material herein contained is the result of a study of 1,000 cases of chronic or recurring pain in the lower part of the back, which, in the majority of cases, radiated down one extremity and occasionally down both extremities.

The average patient in this series who had suffered pain for a considerable length of time had lost faith in all forms of therapy. The patients frequently gave histories of having had their tonsils and teeth, and occasionally their appendices, removed. In the case of a male, it was generally found that the prostate had been massaged on numerous occasions, and, in the case of a female, one or more pelvic operations had usually been performed. In addition, these patients had been treated by chiropractors and physical culturists, without any appreciable or lasting relief from symptoms.

The knowledge gained from the extensive study of the intervertebral disc in recent years by such men as Schmorl, Schanz, Beadle, Lyon, Haumann, Calvé and Galland, and Compere and Keyes, if applied practically to the clinical case, will eliminate many of the useless forms of therapy employed today. It is true that infection and congestion play a part and in many cases undoubtedly bring the symptoms into prominence; however, this is true of any mechanically altered articulation which is under strain. The author is convinced that such factors are secondary in nature and that the primary pathological change is a mechanically altered lumbosacral articulation, resulting in most cases from changes in the intervertebral disc.

The disc furnishes the intervertebral support and keeps one vertebral body separated from its adjacent segments. It also maintains the articular surfaces of the facets in their proper relationship with each other. With the destruction of the disc, the vertebral body above settles and approximates the segment below. In so doing, this body carries with it its inferior articular facets, causing a partial subluxation of the joints formed by its inferior facets and the superior facets of the vertebral segment below. This, in turn, causes a constriction of the foramina through which the segmental nerve roots traverse. Any mechanically altered

* Material used in this study was presented in the Scientific Exhibit at the Annual Meeting of the American Academy of Orthopaedic Surgeons in St. Louis, Missouri, in January 1936. Also, part of this material, with clinical cases, was presented at the Meeting of the Clinical Orthopedic Society in Dallas, Texas, October 30, 1936.

** Part II, dealing with chronic traumatic destruction of the lumbosacral intervertebral disc, will be published in the July issue of *The Journal*.

joint in which the relationship of the normal weight-bearing articulating surface has been disturbed will, after a period of time, show degenerative arthritic changes. Lange, in his recent monograph, has called attention to the fact that the microscopic findings in these mechanically altered facet articulations are the same as those found in hypertrophic arthritis of the hip. Haumann states that "without pathological changes in the disc one cannot have spondylitis".

The component parts of the intervertebral disc are: the nucleus pulposus, the annulus fibrosus, and the two cartilaginous plates.

It has been shown that it is the nucleus pulposus, rather than the annulus fibrosus, that furnishes the intervertebral support. With a loss of function of the former, the latter undergoes an atrophic degenerative change. Hildebrandt and Lyon have described these degenerative changes. The function of the annulus fibrosus is that of a limiting structure for the nucleus pulposus, as is also that of the cartilaginous discs. Acute traumatic compression may so increase the pressure within the nucleus pulposus that either a herniation of the cartilaginous plates, as shown by Schmorl, or a rupture of the annulus fibrosus may take place. In either event the intervertebral space becomes narrower and a partial subluxation of the joints formed by the facets results. Due to the physical properties of the intervertebral disc, a sudden rupture of the nucleus pulposus is more likely to occur in young adult life than it is in a later period of life, after chronic traumatic degenerative changes have taken place and the viscous content of the nucleus pulposus has been replaced by fibrous tissue.

Chronic traumatic compression over a prolonged period of time results in degenerative changes in the intervertebral disc. There seems to be some difference of opinion as to where these changes first take place. Keyes and Compere state that "in discs unaffected by pathological processes, the nucleus pulposus retains its semigelatinous consistency even beyond the fifth or sixth decade". This leads one to believe that the fibrous degenerative change in the nucleus pulposus, so frequently seen in the third and fourth decades of life, is not a natural change, but one due to a pathological process. That such a process is the result of chronic trauma and probably occurs first in the limiting annulus fibrosus is suggested by the fact that a narrowing of the intervertebral joint spaces occurs during the third decade of life on the concave side of all spinal curvatures whether they be scoliosis, lordosis, or kyphosis. In such a spine the weight is not supported by the nucleus pulposus as it should be, but is transmitted from one vertebra to another through that portion of the annulus fibrosus which bounds the concavity of the curve. Since this is not a supportive structure, a traumatic degenerative change takes place as the individual grows to adult life and thereby increases the load. These degenerative changes, as suggested by Schmorl, open avenues of escape for the gelatinous nuclear content, and a gradual narrowing of the joint spaces results. All curvatures eventually may result in symptoms,

due to the mechanical alteration of the joints formed by the facets. However, symptoms resulting from a lordosis are likely to be more severe, in that a settling of the discs posteriorly not only causes a subluxation of the facets but also a constriction of the foramina.

The intervertebral disc between the fifth lumbar and the first sacral vertebrae is subject to more trauma, both acute and chronic, than any other intervertebral disc. This is due to the facts that it carries a heavier load and that the lordosis is greater at this site than at any other part of the spine. This disc is found by x-ray to be destroyed more frequently than any other. The next most commonly destroyed is that between the fourth and fifth lumbar vertebrae.

FIG. 1

The lumbosacral intervertebral disc is destroyed more frequently than any other, the next most common being that between the fourth and fifth lumbar segments. The latter causes segmental symptoms throughout the distribution of the fourth lumbar nerve.

The writer has never seen a herniation of the nucleus pulposus through the cartilaginous plates into the bony substance of the vertebrae, as described by Schmorl, at the lumbosacral articulation. This is undoubtedly due to the fact that the weight, instead of being transmitted through the nucleus pulposus to the first sacral segment, is received to a large extent by the posterior fibers of the annulus fibrosus. The author is convinced that the nuclear content escapes through the damaged posterior fibers of the annulus fibrosus, as shown in Figure 2.

The clinical symptoms emanating from such a lesion are of two sources. The first to appear are those resulting from the subluxation of the facets. This may manifest itself in the form of a chronic low-back pain with periods of increased severity following unusual movement at this site, or symptoms may appear in the form of attacks following unusual strain and commonly spoken of as "lumbago". The other symptoms make their appearance later, after degenerative changes of the disc have progressed sufficiently to cause a constriction of the foramina great enough to result in an irritation of that portion of the nerve which Sicard has called "the funic-

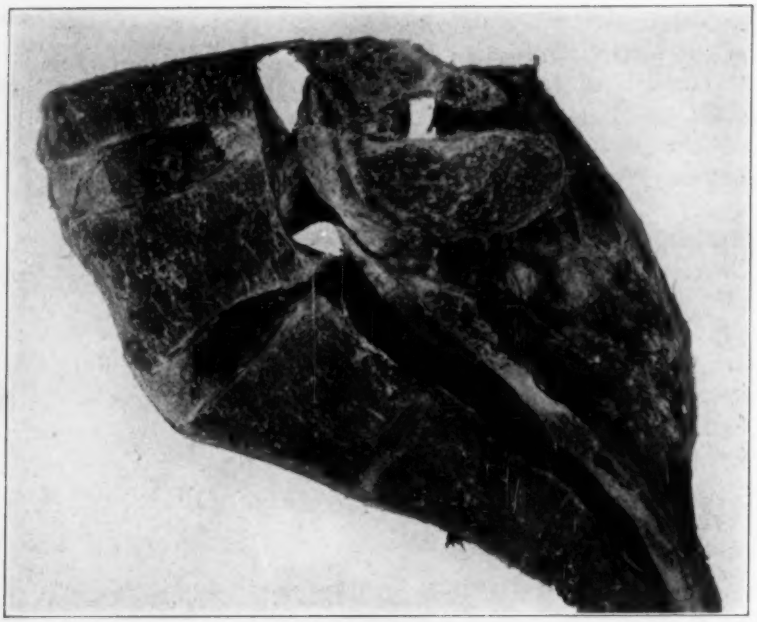

FIG. 2

Anatomical specimen, showing posterior prolapse of the nucleus pulposus into the neural canal.

ulus". At this stage, the syndrome presented is that which is so frequently diagnosed as "sciatica", but which in truth is a neuralgia or a neuritis of the fifth lumbar nerve, depending on the degree of nerve involvement.

Hypertrophic degenerative changes soon appear around the margins of the facets. These add to the possibility of nerve-root involvement. Lipping also appears around the inferior margin of the fifth lumbar vertebra and is undoubtedly due to abnormal stress between two bony surfaces which normally are protected from one another by the resilient supportive nucleus pulposus.

The author is unable to agree with those who say that an escape of the nuclear contents elsewhere in the spine does not cause clinical symptoms. During the past year he has seen eight such cases in which the nucleus involved was located within the thoracic spine. Most of these patients had been treated for gall-bladder and stomach disorders. A topographical neurological examination usually revealed a hyperalgesia over the sensory distribution of the nerve involved and there was tenderness to thumping over the corresponding vertebral segment. The roentgenograms showed a localized hypertrophic arthritis at this site with a narrowing of the intervertebral space. The usual diagnosis made in such a case is hypertrophic arthritis without regard for the destruction of the supportive nucleus pulposus which is probably the primary pathological change, the hypertrophic arthritis being the result of abnormal stress which followed destruction of the disc.

A thorough knowledge of the mechanics of the lumbosacral spine is important in the diagnosis and in the treatment of lesions at this site. In this connection it is well to call attention to the fact that the entire weight of the torso is transmitted to the lumbosacral disc as a forward sheering force. Anterior displacement is prevented by the first sacral facets which normally are located anterolaterally to the inferior fifth lumbar facets.

Flexion of the spine causes a compressive force on the anterior margins of the intervertebral discs and an increase in diameter of their corresponding foramina. Extension of the spine causes a compressive force on the posterior margins of the intervertebral discs and a constriction of their corresponding foramina. This undoubtedly accounts for the pain in the lower back and leg occasionally observed in patients convalescing from a compression fracture of the spine. Lateral flexion likewise causes a compression of the lateral margin of the discs with a partial closure of the foramina on the same side and a widening of those on the opposite side.

The plane of the articular surfaces of the first sacral facets is frequently down and backward. Since the inferior fifth lumbar facets are locked over the first sacral facets, a settling of the fifth lumbar segment takes place in a downward and backward plane, producing a posterior displacement of the fifth lumbar vertebral body in its relationship to the first sacral segment. The greater the lumbosacral angle, the more marked is the posterior tilt of the first sacral facets and thus the greater the posterior displacement of the fifth lumbar vertebra.

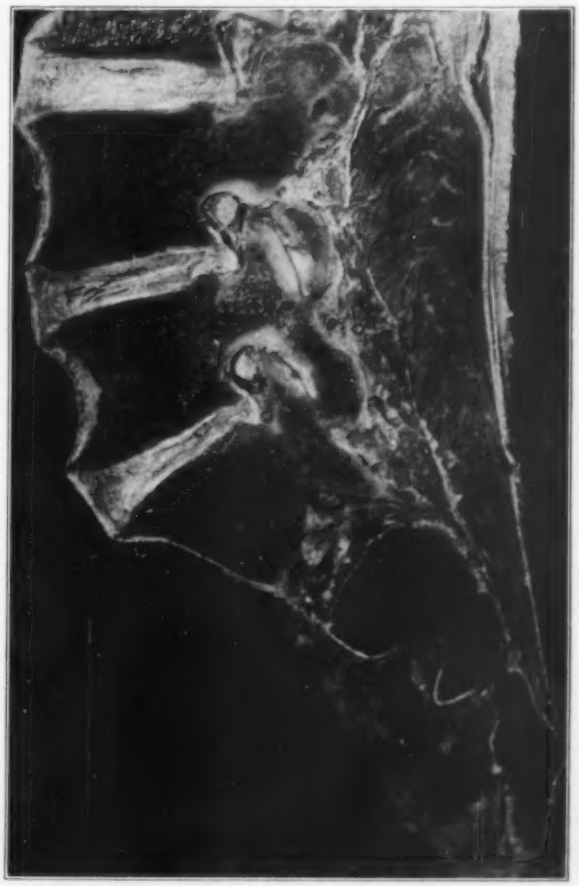

FIG. 3

Anatomical specimen, showing subluxation of the lumbosacral facets and impingement of the fifth lumbar nerve by the first sacral facet. (*Courtesy of Dr. Yglesias.*)

FIG. 4

As the disc settles, the fifth lumbar vertebra is pulled backward if the articular surfaces of the first sacral facets are in a downward and backward plane.

This mechanical alteration has recently been described as a primary pathological entity, but its occurrence is only secondary to a thinning of the lumbosacral intervertebral disc. Contrary to recent reports by Willis and Reynolds that such a displacement is an optical illusion, the author believes it to be an actual displacement which follows natural laws. Due to the absence of soft tissues, the writer considers museum material worthless in proving the point.

The extensor muscles of the human spine are overdeveloped, due to the continued effort involved in maintaining the erect posture against gravity. This overdevelopment has been accomplished at the expense of the antagonistic flexor muscles. The imbalance between the two groups of muscles has resulted in a deformity of the low spine in the form of a lumbosacral lordosis. This is undoubtedly a pathological deformity, but, due to its universal appearance, we must consider it the normal as determined by the law of averages.

The principal muscles of extension are the sacrospinalis group. A contraction of this group, when a person is in a flexed position with gravity counteracting the muscle pull, results in a vertical compression of the lumbar vertebrae and their intervertebral discs. The compressive force increases in proportion to the load lifted. As the person approaches the erect posture, the lumbosacral spine assumes a position of extension and the contraction of the sacrospinalis then compares favorably to the action of a bow string. The vertical compressive force shifts from the anterior margins and nuclei pulposi to the posterior margins of the intervertebral discs. The significance of these mechanical principles of the lumbosacral articulation will be emphasized under the treatment of the various lesions of this site.

Table I gives the pathological lesions of the lumbosacral spine and their frequency of occurrence as determined by clinical and roentgenographic studies.

TABLE I

FREQUENCY OF OCCURRENCE OF PATHOLOGICAL LESIONS OF THE LUMBOSACRAL SPINE IN 400 CASES

Lesion	Cases	Per Cent.
Destruction of the lumbosacral intervertebral disc	285	71.25
Lumbarization of the first sacral segment	35	8.75
Imperfect fusion of the sacral lateral masses	31	7.75
Sacralization of the fifth lumbar vertebra	28	7.00
Spondylolisthesis	13	3.25
Facet fragmentation and anomalies	8	2.00
Total	400	100.00

The material in this report has been collected over a period of four years and is a study of 1,000 cases. However, since the significance of an imperfect fusion of the sacral lateral masses was not appreciated until after the first 600 cases had been collected, the frequency of occurrence of the various lesions has been determined from only the last 400 cases.

The omission of the disorders of the sacro-iliac synchondrosis as a primary etiological factor in this classification will undoubtedly be questioned by many; however, the author has found neither anatomical, roentgenographic, nor clinical evidence to support such a hypothesis. A secondary sacro-iliac arthritis is a common finding in those cases showing an imperfect fusion of the sacral lateral masses.

The study of the routine anteroposterior and lateral roentgenograms of the lumbosacral spine rarely reveals the cause of symptoms in this group of patients. Recent experience has taught us that we can no longer focus our attention on the vertebral body alone for evidence of destructive lesions, of compression fractures, and of hypertrophic arthritis. The pathological change is usually found to involve the intervertebral disc and the articular facets. This demands the employment of a more careful technique in posing the patient, in order that the site in question may not be hidden by superimposed bony structures. A routine technique which has been used with success in these cases has recently been described by Dr. Wigby and the author.

It is impossible in all cases to determine whether or not the destruction of the intervertebral disc has resulted from an acute or from a chronic injury. For this reason it is necessary to combine the two groups in reporting their occurrence. However, the clinical history and the roentgenographic findings vary to such an extent in individuals that the

writer is convinced that we are dealing with two groups of patients and for this reason they will be discussed separately. A tuberculous destruction of the lumbosacral disc occurred four times in this series and these cases are included in this classification. They will also be discussed separately.

A careful history obtained from these cases, whether the etiological factor be acute or chronic trauma, will convince the clinician that he is dealing with a disease which is aggravated by position, and thus is probably mechanical in nature.

There have been several men who have called attention to lesions of the lumbosacral articulation in patients suffering with symptoms in the lower part of the back. In this connection, the work of Goldthwait, Danforth and Wilson, Putti, Ayers, Bársony, and Kienböck should be consulted. Ayers was the first to emphasize the significance of a narrowed disc in its relation to symptoms in the lower part of the spine and the extremities.

ACUTE TRAUMATIC DESTRUCTION OF THE LUMBOSACRAL INTERVERTEBRAL DISC

FIG. 5

Acute traumatic destruction of the lumbosacral intervertebral disc. Note the constriction of the lumbosacral foramina.

The roentgenographic appearance of the lesion is shown in Figure 5.

It is the writer's belief that a rupture of the nucleus pulposus not infrequently takes place as a result of a compressive force which occurs during young adult life. Clinical symptoms in this group of patients appear at an earlier age and are usually more severe in character than those appearing at a later period and resulting from a chronic traumatic or postural change. Clinical symptoms and roentgenographic findings suggestive of the acute traumatic lesion are found nearly twice as frequently in men as in women. This can undoubtedly be explained by the more strenuous physical activity on the part of the male.

History

The most common his-

tory obtained is that at some time between the ages of fifteen and twenty-five the patient suffered an injury to the low back. The mechanics is usually compressive in character, such as a fall on the buttocks. Occasionally a definite snapping sensation is experienced at the time of the injury and within a few hours pain develops in the lower part of the back. The patient usually obtains relief from symptoms after a few days, and the injury is considered trivial in nature. Sometime later, varying from a few weeks to several years, while lifting a load or bending backward, the patient again suffers a severe attack of pain in the lower part of the back. Symptoms may come on immediately or they may make their appearance within a few hours. The condition at this time is diagnosed as lumbago, and the patient is treated with some form of fixation, heat, and removal of all possible foci of infection. A gradual relief from symptoms results.

Such attacks may occur repeatedly at irregular intervals and sooner or later the symptoms in the lower part of the back are accompanied by pain radiating down one extremity, and occasionally both extremities, to the lateral aspect of the calf and the ankle. At this stage the usual diagnosis is sciatica, and the patient is rarely ever entirely free from some discomfort, either in the low back or in the legs; this is particularly true during the winter months. A frequent history obtained at this stage is that the patient sleeps on his side with one knee or both knees drawn up and he sits in a slumped position with his feet elevated. During acute attacks, coughing and sneezing severely increase the pain.

Severe exacerbations continue to occur following trauma until about the sixth decade of life, which corresponds to that period in life when degenerative changes are likely to bring about a natural fixation. During this period symptoms frequently disappear entirely.

The most constant physiological principle involved in recurrent attacks is a contraction of the sacrospinalis muscles with the lumbosacral spine extended. In those cases in which lifting is given as the cause, a detailed history will reveal that the injury did not occur until the patient had lifted the load to such a height that the lumbosacral lordosis was restored. Occasionally the lifting of the weight of the torso alone against gravity is sufficient to initiate an attack. Many recurring attacks are brought on by playing golf, most of which can be traced to the use of a wooden club, where a contraction of the sacrospinalis muscles and extension of the spine are necessary in the execution of a drive. Symptoms which appear while the patient is playing a game of tennis are usually first noticed when he is serving the ball. Here again, it is necessary to contract the sacrospinalis muscles and to arch the back.

The following case history is given in brief to illustrate the type of case under consideration:

A male, aged thirty-seven, weight 168 pounds, height seventy-two inches, gave a history of having fallen from a buggy at the age of fifteen, landing on his buttocks. Severe pain in the lower part of the back had followed and he had been forced to remain in bed for a period of about one week. A gradual relief from symptoms had resulted.

He had experienced no further symptoms until the age of twenty-five, when a similar severe attack of pain in the lower part of the back had been initiated by the lifting of a load. The condition had been diagnosed as lumbago, and the patient had been ordered to bed, where he had remained for a period of ten days. Again a gradual relief from symptoms had resulted. Intermittent attacks had occurred on an average of about once a year thereafter until about eighteen months before he was seen by the author, at which time the symptoms became more or less continuous and pain began radiating down the back of the right thigh to the side of the calf and the ankle. He was unable to sleep on his back, but was fairly comfortable when on his side with his knees drawn up. He was more comfortable when sitting on a footstool than he was when sitting in a chair. When sitting in a chair he was more comfortable in a slumped position with his feet elevated.

There is a certain percentage of patients who never experience pain other than in the lower part of the back and gluteal region, although the history and findings are characteristic of the acute traumatic lesion. It is possible that pain along the course of the fifth lunbar nerve appears at a later date; however, the roentgenogram may show a complete settling of the fifth lumbar segment at the time of examination. Such a condition is found more frequently in women than in men, and it is probable that, due to a slight individual variation in the architecture of the lumbosacral facets, the nerve root escapes impingement even though the foramina are partially constricted in these cases.

It is not uncommon in women whose roentgenograms present the findings characteristic of the acute traumatic lesion to obtain a history to the effect that symptoms appeared following the birth of a child. Uterine contractions are frequently accompanied by a severe arching of the lumbosacral spine, due to a powerful contraction of the erector spinae muscles. It is possible that the compressive force on the posterior margin of the lumbosacral intervertebral disc becomes so great at such a time that the annulus fibrosus is ruptured and an escape of the nuclear content follows.

Symptomatology

The symptoms and clinical findings vary widely with the progressive course of the disease as well as with the severity at the time of the examination.

At the time of the original acute injury the patient complains of pain in the lower part of the back. All spinal motions increase its severity. The patient walks with a protective gait and gets up and down with great care, trying to avoid any sudden movement. The sacrospinalis muscles are frequently in spasm, and pressure over them causes pain. There is usually tenderness to pressure over the lumbosacral articulation. All spinal motions are severely limited. A deviation of the spine is an uncommon finding at this stage of the disease. In recurrent attacks symptoms are usually spread to a larger area. A sciatic scoliosis is a common finding. The lumbar lordosis is usually reduced and not infrequently replaced by a mild kyphos at this site. While standing or sitting, the patient takes his weight on his elbows when possible. When designating the areas in which he suffers pain he usually places his hand over the

lumbosacral and upper gluteal regions. Lumbosacral and sciatic-notch tenderness are more prominent findings during the recurrent attacks. There is usually tenderness to pressure over the distribution of the superior gluteal nerve. It is evident at this stage that there are beginning segmental nerve symptoms. Extension of the spine increases the severity of pain, as does also a combination of extension and lateral flexion to the side affected when symptoms are unilateral. Extension of the knee with the hip flexed frequently refers pain to the lumbosacral region.

After segmental symptoms have become more pronounced and the patient complains of pain radiating down the leg, the symptoms and clinical findings vary considerably with the degree of severity,—that is, they depend on whether the patient is suffering an acute severe attack or whether the symptoms are chronic in character. During an acute severe attack, the symptoms differ from those already described in the recurrent attacks of pain in the lower part of the back. The lumbar lordosis is more frequently replaced by a mild kyphosis, and, in extremely severe cases, instead of the usual spinal list the patient presents an attitude in which the trunk is flexed almost to a right angle as shown in Figure 6.

FIG. 6

Flexion attitude assumed in severe cases of impingement of the fifth lumbar nerve. This patient had maintained this attitude for eight months. Complete relief followed facetectomy and fusion.

Such a patient is unable to straighten up and, in attempting to do so, extends the lumbothoracic spine without affecting the kyphosis of the lumbar region. He usually stands with the hip and knee slightly flexed on the side principally affected. Extension of the knee with the hip flexed is limited, due to a protective voluntary contraction of the hamstring muscles. This manipulation produces pain in the lumbosacral region, along the course of the sciatic nerve, and occasionally a tingling sensation on the lateral aspect of the calf and the ankle. A hyperalgesia over the lateral aspect of the calf and the ankle is a common finding. Not infrequently pain is present and there is a sensory change in the form of a hyperalgesia throughout the distribution of one or more of the first three sacral nerves.

In the patient in whom segmental symptoms have become chronic in character there is usually an atrophy of the thigh and the calf. The spinal list is less severe, or it may be entirely lacking. Flexion of the lumbosacral articulation is limited and can be determined by attempting to draw the knees to the axillae. Hamstring limitation is frequently observed and is due usually to a fixed posterior rotation of the pelvis rather than to shortening of the hamstring muscles. The lateral aspect of the

FIG. 7

Section of the first sacral facet removed at operation, showing the sclerotic bone with denuded articular surface (upper border).

calf and the ankle—that is, the sensory distribution of the fifth lumbar nerve—instead of presenting a hyperalgesia, more frequently presents a hypalgesia or anaesthesia, but segmental symptoms throughout the distribution of the sacral nerves are usually less marked. The Achilles-tendon reflex is commonly diminished and occasionally absent. It is evident at this stage, both from the distribution of pain and from the nerve changes, that we are dealing with a lesion involving primarily the fifth lumbar nerve, and that the term "sciatica" is misleading when applied to these cases.

In six cases in this series there was a marked weakness of those muscles in the leg which receive their nerve supply through the fifth lumbar nerve. In four cases the paresis had progressed to such a stage that drop-foot had developed.

Pathology

It is the author's belief that the lesion under consideration is due to a rupture of the posterior fibers of the annulus fibrosus. This permits an escape of the nuclear content. Patients do not die of this disease and for this reason microscopic studies of the disc following the original injury are practically impossible to obtain. Figure 2 shows a herniation of the nucleus pulposus of the lumbosacral intervertebral disc through the posterior fibers of the annulus fibrosus. The nuclear content extends posteriorly into the neural canal. The writer has found three such

specimens in the anatomical laboratory. Badgley recently observed this finding at the post-mortem examination of a patient who had been suffering from the symptoms already described.

Following the escape of the nuclear content, a degenerative change in the disc soon takes place. Compere and Keyes permitted an escape of the nuclear content by incising the anterior fibers of the annulus fibrosus of a dog. Three months later the dog was sacrificed. They found "typical degeneration and fibrosis of the remaining nucleus pulposus and annulus fibrosus". The cartilage plate also showed degeneration, while sclerosis of the bone extended deep into the cancellous portion of the vertebral body. Anteriorly there was beginning osteophyte formation.

A secondary pathological change takes place in the facets as a result of a mechanical alteration which is brought about by the settling of the disc. This is a degenerative arthritic change. Lange states that "the result of the positional changes is that the joints show wear prematurely and an arthrosis deformans develops early". He also states that "the law of functional overburdening has the same significance for the development of the arthrosis deformans in the articulations of the vertebral processes as it has for the development of arthrosis deformans in the joints of the extremities". Figure 7 shows the microscopic degenerative changes of a first sacral facet removed by operation.

The pathological findings, both microscopically and macroscopically, are marginal bony proliferation, sclerosis, and destruction and atrophy of the cartilaginous articular surfaces.

The neuropathological changes present an extremely important phase in the treatment of these patients, yet it is the one concerning which we have the least knowledge.

The funiculus, or that part which traverses the foramen, does not lie within the arachnoid as does the intraspinal portion of the nerve. It is covered by a prolongation of the dura mater around the circumference of which is a rich venous plexus. The nerve at this site is not protected by the cerebrospinal fluid and is, therefore, more liable to external injury than the intraspinal portion of the nerve. The plexus of veins is also subject to irritation from the surrounding foramen, and undoubtedly a traumatic inflammatory congestion results at this site following any mechanical irritation.

Silbermann suggests as a cause of certain cases of sciatica inflammation of the soft meninges, especially of the arachnoid. It is possible that congestion of the venous plexus could result in pathological changes of sufficient severity to extend into and to involve the arachnoid. It is also very probable that the posterior prolapse of the disc into the neural canal, in certain cases, is of such magnitude that it causes a traumatic inflammation of the meninges and not infrequently actual pressure on the sacral-nerve roots. This probably explains the associated sacral symptoms seen in many of these cases in the acute stage. However, the

primary and persistent segmental symptoms are found throughout the distribution of the fifth lumbar nerve and cannot be explained on the basis of a prolapsed lumbosacral disc, due to the fact that the nerve emerges from the neural canal above the posterior prolapse of the intervertebral disc. The author found in a patient recently operated upon that the funicular portion of the nerve showed evidence of scarring and that it had become so adherent to the capsule of the joint formed by the lumbosacral facets that it was necessary to allow a portion of the capsule to remain attached to the nerve after the facets had been removed. Meningeal adhesions were observed by the author at operation in a patient whose roentgenograms showed a narrowing of the lumbosacral intervertebral disc, and who presented clinical findings characteristic of this lesion.

The neural pathology of this lesion still presents an open field for investigation. The recent work of Mixter and Barr and Mixter and Ayer will undoubtedly afford invaluable information in this regard.

Roentgenographic Findings

The principal roentgenographic findings are a narrowing of the lumbosacral disc and a constriction of the lumbosacral foramina. When the articular surfaces of the first sacral facets are in the transverse plane, it is not uncommon to find that, in the process of settling, the fifth lumbar vertebra has been displaced slightly backward in its relation to the first sacral segment. Hypertrophic marginal changes and sclerosis about the facets are frequently observed. Also, osteophyte formation around the inferior margin of the fifth lumbar vertebra and the superior margin of the first sacral vertebra may be apparent in chronic cases.

It is impossible by roentgenographic studies to state definitely in all cases whether the etiological factor concerned in bringing about the destruction of the disc was an acute or a chronic injury. However, in a certain percentage of cases the roentgenogram affords the best means of a differential diagnosis. In cases in which the narrowing of the intervertebral disc is confined to the lumbosacral spine alone, it is very suggestive of an acute traumatic origin. This is particularly true when an exaggerated lumbar lordosis is present. In such a case, if the trauma had been of a chronic character, the narrowing would not have been confined to the lumbosacral disc alone, but would have involved the other intervertebral discs of the lumbar spine. It is also very suggestive in cases where the patients present good posture,—that is, where the lordosis is not of a degree severe enough to bring about chronic degenerative changes, yet the roentgenograms show a marked narrowing of the lumbosacral intervertebral disc.

After chronic degenerative changes of a postural nature have resulted in a generalized narrowing of the posterior portion of the lumbar intervertebral discs it is impossible to say whether the more severe settling of the lumbosacral disc is the result of acute or of chronic trauma.

The narrowing of the lumbosacral disc may include only the posterior half, the anterior portion retaining its normal width; or it may include the entire disc, depending considerably upon the tilt of the sacral table.

Treatment

From a study of the pathological changes which have taken place in these cases it becomes evident that treatment, both conservative and surgical, must be aimed at accomplishing two mechanical principles,—first, a widening of the posterior half of the lumbosacral intervertebral joint space, and thus an opening of the lumbosacral foramina, and, second, an elimination of motion at the lumbosacral articulation.

FIG. 8

Flexion body jacket used in the treatment of patients with acute symptoms. As the patient assumes the erect posture, the sacrum is forced forward and the reduced lumbosacral angle is maintained.

In patients whose roentgenograms show a complete loss of the lumbosacral intervertebral space posteriorly, it is possible, by taking a lateral roentgenogram of the lumbosacral articulation with the patient in a position of acute flexion (accomplished by drawing the knees to the chest), to demonstrate an increase in the width of the posterior portion of the lumbosacral intervertebral space and an increase in the diameter of the corresponding foramina. It is on these findings that all treatment must be based. We must bear in mind that we are dealing with a disease which cannot be corrected from a pathological standpoint. This is due to the fact that, after the intervertebral disc has once been destroyed, a regeneration does not take place. For this reason, our efforts must not stop when relief from the acute attack has been accomplished, but we must go further and attempt to bring about a permanent reduction of the lumbosacral lordosis and thereby approximate the normal diameter of the lumbosacral foramina indefinitely. It is impossible to report statistics on cures, as a cure is never surely permanent until an internal fixation of the lumbosacral region has been accomplished by surgical interference or by natural degenerative changes.

The most gratifying results obtained in relieving the acute symptoms have been accomplished through the application of the principles already mentioned. If a patient presents himself suffering with acute symptoms—whether it is following the original trauma in young adult life, or during a recurrent attack, or during a chronic stage of sciatica—the primary treatment is the same. With the patient standing and with the spine flexed sufficiently to eradicate the lumbosacral lordosis, a plaster-of-Paris

jacket is applied. This position is best obtained by having the patient rest his weight on his elbows, supported by a table the height of which is at about the level of the margin of the lower rib. Posteriorly, the cast extends from the scapulae down to about the third sacral segment. Anteriorly, it extends down to the superior margin of the pubis, but it is trimmed in such a manner that it permits right-angle flexion of the hips without interference from the lower border of the cast, as shown in Figure 8.

When the patient attempts to assume the erect posture after the cast has been applied, he experiences pressure over the buttocks, which forces the sacrum and pelvis forward. The lumbosacral lordosis is reduced and cannot be restored as long as the patient remains in the plaster cast. The eradication of the lumbosacral lordosis causes a partial restoration of the posterior width of the lumbosacral intervertebral space and an increase in the diameter of its corresponding foramina.

Some patients are permitted to continue ambulatory and are instructed to sleep on their backs with the knees propped up. However, most patients are put to bed for a period of ten days or longer, depending on the relief from symptoms. It is important that the patient be maintained in the proper position. The position of choice is on the back with the hips and knees flexed to an angle of about 45 degrees. This position can easily be obtained in the modern hospital bed, as shown in Figure 9.

In order to permit the back of the cast to dry, and to avoid tiresome fixation on the back, the patient is allowed at intervals to turn on either side, but care should always be taken to maintain the flexion of at least one hip and knee. The principal advantage of bed rest for such a period of time is that it permits the traumatic inflammatory reaction about the funicular portion of the fifth lumbar nerve to subside, while fixation in plaster prevents further irritation of the swollen and oedematous structures. After symptoms have subsided to a considerable extent, the patient is permitted to become ambulatory with the cast on. The cast is worn for from one to two weeks.

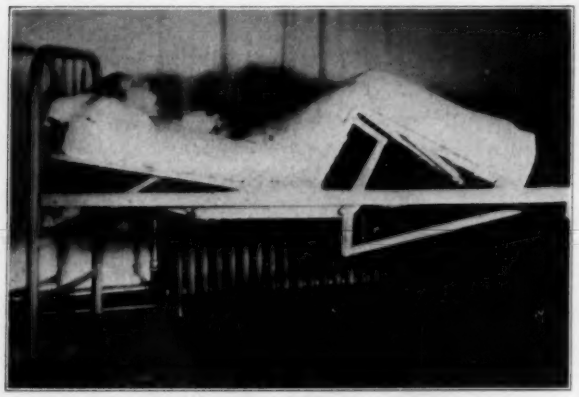

FIG. 9

Flexion attitude employed in relieving acute cases. A similar attitude is advised as a permanent sleeping position for those who suffer at night.

The author is opposed to most manipulations on these patients, particularly any form which involves a stretching of the hamstrings or an extension of the lum-

bosacral spine. The nature of the lesion itself contra-indicates any such action. In fact, at no time during the course of treatment should these patients be permitted to extend the spine.

In acute cases the muscle spasm may be so severe that the desired flexion cannot be obtained. It is well in such cases to remove the cast after a period of ten days and to reapply it. Symptoms have usually subsided considerably and flexion can be more readily obtained. Occasionally it is necessary to remove the cast and to fix the patient with the knees drawn to the chest in order to obtain relief from symptoms. Traction on the affected extremity is frequently an aid in that it may help to open the foramen on that side; however, flexion should not be sacrificed for its use.

After the patient has been ambulatory for from one to two weeks in a flexion cast, the cast is removed and a lordosis brace is substituted. The brace should be so designed as to maintain the eradication of the lordosis of the lumbosacral spine. Such a brace will be described in Part II of this paper. There are some cases in which an orthopaedic corset is sufficient. However, while such garments give partial fixation, they do not afford any appreciable eradication of the lumbosacral lordosis and in many cases they actually interfere with the patient's voluntarily maintaining the corrected position.

Patients past the age of forty-five should be instructed to wear the brace for from six to twelve months. This permits time for the lumbosacral angle to become reduced and partially fixed in the corrected position. These patients should be instructed in postural exercises, in order to obtain a balanced muscle tonus, and should be taught proper positions, both of which will be described under the treatment of the chronic traumatic destruction of the intervertebral disc in Part II.

The length of time during which the brace is worn by patients under the age of forty-five depends considerably on the posture of the patient. The average length of time is from three to six months.

The patient under forty-five who presents an exaggerated lordosis of the lumbosacral spine offers a better prognosis for the prevention of recurrent attacks than those with good posture. This is due to the fact that in eradicating the lordosis in the former group the pelvis rotates forward through a greater arc than in the latter, thereby affording a wider restoration of the posterior width of the lumbosacral foramina. However, unless premature degenerative changes have taken place, all patients under forty-five are given a strenuous course in postural exercise and instructed in positions. As soon as an eradication of the lumbosacral lordosis has been obtained and can be maintained voluntarily, and when the patient thoroughly understands the mechanics of his lesion, the brace can be discontinued.

The young individual whose roentgenograms show a complete loss of the lumbosacral disc and whose clinical examination reveals a good posture—that is, a practically straight lumbosacral spine—presents the

most difficult problem in obtaining satisfactory relief from symptoms by conservative methods. Recurrent attacks are liable to be frequent in this type of case, and surgical measures may have to be employed.

Women frequently object to wearing a metal brace and for this reason corsets have to be used. When it is evident that a better means of fixation and correction is indicated, a light celluloid jacket can be made from a mold taken with the lordosis reduced. This is best accomplished by having the patient sit on an ordinary operating-room stool, with the feet propped up so that the knees are slightly higher than the hips.

When symptoms are confined to one extremity, an elevation of one-half an inch on the heel of the unaffected side frequently aids remarkably in relieving symptoms. This is due to the fact that such a lift tends to open the lumbosacral foramen on the opposite side. However, such a lift must be employed with caution, as it also tends to constrict the lumbosacral foramen on the unaffected side and in a few cases the writer has seen symptoms shifted from one extremity to the other as a result of its use.

In those cases in which all forms of prolonged conservative treatment fail, surgical treatment is indicated. In this series of cases thirty-six operations have been performed. Five were for spondylolisthesis; seven, for lumbosacral anomalies; three, for an anomaly plus a reduced lumbosacral joint space; one, for fragmentation of the inferior fifth lumbar facet, probably traumatic; and twenty, for destruction of the lumbosacral intervertebral disc, three of which were due to tuberculosis and the remaining seventeen, with the exception of one, the author believes were due to acute rather than to chronic injury.

Of the latter group nine were treated by lumbosacral fixation alone, while eight were treated by lumbosacral fixation and removal of the lumbosacral facets on the side principally affected. In two cases the fixation and the facetectomy were done at different stages. The facetectomy was resorted to because the fixation failed to give relief from symptoms referable to the fifth lumbar nerve. Lasting relief has been obtained in all of the seventeen cases with the exception of one in which the patient died after the operation, due to a streptococcal infection of the blood stream.

When symptoms are segmental in character, the author is of the firm belief that the operation indicated in these cases consists of fixation of the lumbosacral spine and opening of the foramen by removal of the facets on the side principally affected. Differing from the former report by Dr. Yglesias and himself, the writer advises that the fusion and the facetectomy be done at the same time, thereby avoiding the second operation in cases where fusion alone fails to give relief. In those cases in which pain has always been confined to the lower part of the back and in which clinical examination fails to reveal any evidence of peripheral nerve changes, lumbosacral fusion alone is indicated.

From the clinical findings and the operative results, the author finds no justification for including a fusion of the sacro-iliac joint unless a de-

velopmental imperfect fusion of the sacral lateral masses is also present. Operative results and procedures in the other cases will be discussed under their proper classification.

Aside from the orthopaedic treatment of these patients, a conservative program should consist of removal of all definite foci of infection, as they are contributing factors in the production of symptoms in any mechanical lesion of the skeletal system. However, pain in the lower part of the back and in the extremities is not an indication for the removal of uninfected teeth, tonsils, or the appendix. Neither is it an indication for questionable pelvic operations, until thorough clinical and roentgenographic examinations of the lumbosacral spine have failed to reveal evidence of pathological change.

All such patients should be examined by a neurologist before surgery is done; however, a thorough knowledge of the lesion under consideration and careful clinical and roentgenographic examinations will differentiate a neuralgia or neuritis of the fifth lumbar nerve from a primary cord lesion. The writer has never seen tabes, diabetes, pelvic tumors, or circulatory changes cause symptoms characteristic of this lesion.

We must constantly bear in mind that there may be more than one lesion of the low spine causing symptoms. The lumbosacral intervertebral disc frequently gives way and undergoes a degenerative change in those cases presenting a lumbarization of the first sacral segment, as well as in those cases showing an imperfect fusion or failure of fusion of the lateral masses of the first and second sacral segments. In such cases, in addition to the pain referable to the fifth lumbar nerve, the patient may complain of symptoms and may present nerve changes throughout the distribution of the first, second, and third sacral nerves. These findings will be discussed under their proper classification.

A thorough knowledge both of the motor and of the sensory distributions of the lumbar and sacral nerves is essential in making an intelligent diagnosis in these cases.

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THE T-SHAPED FRACTURE OF THE LOWER END OF THE HUMERUS

BY W. J. EASTWOOD, M.CH. (ORTH.), LIVERPOOL, ENGLAND

Although this fracture has not received very much attention in the English and American literature during the last fifteen years, it is a reasonably common injury and there are at least four recognized methods of treating it, all of which differ very widely in their application.

The author has recently reviewed fourteen cases of this type of fracture which were treated by a method first recommended by Hugh Owen Thomas and later popularized by Sir Robert Jones, and the results have been so satisfactory that it has not been considered wise to adopt any of the more modern means of reduction and splintage which have the disadvantage that they are difficult to apply and serious complications are not unknown.

The treatment is carried out in the following manner: Under general anaesthesia, the displaced fragments are manipulated into a better position by means of strong traction which the operator applies by gripping the forearm in the upper third while the patient's elbow joint is held at a right angle. At the same time, the fracture is compressed laterally in an attempt to close the gap between the two condyles. The wrist is then slung from the neck in a collar and cuff or halter, the angle between the forearm and humerus being not less than 60 degrees and not more than 90 degrees. No form of bandage or of compression is applied around the elbow itself, nor is the humerus bandaged to the side of the body. It is most essential that the patient should walk as soon as possible, for the success of the treatment depends more on the gradual traction by the force of gravity than it does on the preliminary reduction, which can frequently be omitted without endangering the end result.

Movements of the fingers and hand are encouraged from the first day, but, as the fragments are naturally very mobile, the shoulder joint is not moved during the first fortnight. After this period, union is becoming firm and routine exercises are given to prevent stiffness from occurring in the shoulder. At the same time, gentle active movements at the elbow joint, from the position in which it is fixed toward the position of full flexion, are permitted, provided that these movements are painless. In a month to six weeks from the date of reduction, free movement, from almost full flexion to as far as the right-angle position, will be present in the elbow joint. If this movement is free and painless and there is no tenderness on pressure over the site of fracture, the patient can dress normally, passing his injured arm through the sleeve of his clothes. He must be encouraged to use his arm, in the attempt to increase the extension of the elbow without losing the free flexion which he has already obtained. A sling is carried outside the clothes in which the arm is rested

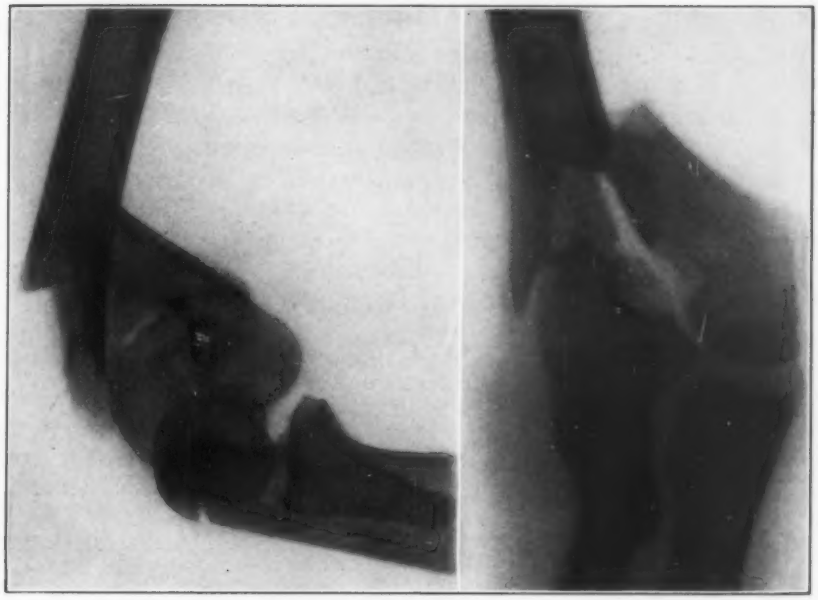

FIG. 1-A

Patient S. D., aged sixteen years, a fitter. Roentgenogram taken on August 2, 1934. Reduction was not attempted. Treatment consisted of a collar and cuff with the elbow at an angle of 60 degrees.

FIG. 1-B

Patient S. D., June 27, 1936. Full flexion and rotation: extension limited by 20 degrees; slight loss of the carrying angle.

for frequent short intervals, as it has been found that too rapid an increase toward full extension only causes a diminution of the more important range of flexion. Massage and passive movements should never be advised at any stage of the treatment, but supervision of the exercises is frequently necessary to avoid disappointment, due to inability on the part of the patient to realize the importance of active movement.

Failure to obtain a satisfactory range of movement may occasionally follow the use of this method just as it may occur after any other type of treatment. The causes of these occasional failures may be attributed to gross destruction of bone involving the head of the radius and the surrounding soft tissues, or to lack of cooperation or misunderstanding of instructions on the part of the patient, or to some slight error occurring in the course of the treatment. The mistakes most

FIG. 2-A

Patient W. B., aged thirty-seven years, a collier. Roentgenogram taken on March 20, 1930. Treatment consisted of a collar and cuff only with the elbow fixed at an angle slightly less than 60 degrees.

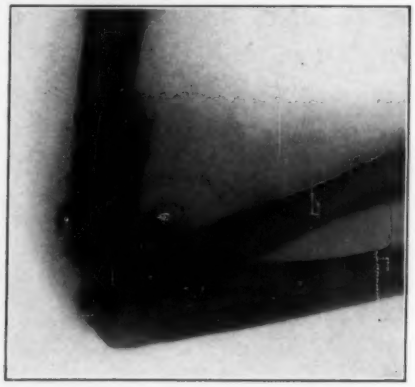

FIG. 2-B

Patient W. B., May 29, 1930, showing the improvement in the position of the fragments, caused by the action of gravity in an ambulatory patient.

commonly seen in the carrying out of this method are:

1. Fixation of the elbow at too acute an angle of flexion at the commencement of treatment, causing the coronoid process to force apart the fragments of the lower end of the humerus.
2. Too long a period of immobilization after bony union has begun.
3. Pressure from overlying clothes which are used to give support for the elbow and which interfere with the free action of gravity on the joint.

Any one of these simple mistakes will cause some loss of movement, particularly that of extension, and to overcome this disability further treatment is sometimes necessary. This is carried out after bony union is firm and when there has been no increase of extension for over two months. The treatment consists of gently forcing the elbow into as much

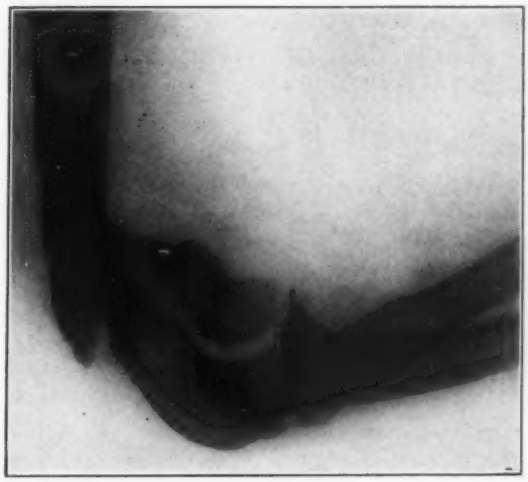

FIG. 3-A

Patient T. S., aged seventeen years, a collier. Roentgenogram taken on August 29, 1933. Reduction under general anaesthesia was attempted, followed by the application of a collar and cuff with the elbow at an angle of 60 degrees.

FIG. 3-B

extension as possible with the patient under general anaesthesia to relax the muscle spasm. When the elbow has been straightened as much as possible, the position is maintained by a plaster slab or metal splint which is kept in place for a fortnight. After this time, the support is removed and the patient is made to use the elbow frequently in order to regain the position of full flexion; at the same time care should be taken to preserve the maximum extension obtained by the manipulation. For an additional four to six weeks the patient wears the support at night to avoid contraction of the tissues in front of the elbow joint during the hours of sleep. This secondary treatment, if carried out gently but firmly when bony

FIG. 3-C

FIG. 3-D

Patient T. S., June 11, 1936. Full movement in all directions; no deformity. Patient back at regular work.

FIG. 4-A

Patient J. G., aged thirty-nine years, a steel erector. Roentgenogram taken on April 9, 1931. Reduction under general anaesthesia was attempted, and the elbow was fixed at an angle of 70 degrees.

FIG. 4-B

FIG. 4-C

Patient J. G., June 11, 1936. Full flexion limited by 10 degrees; full rotations; extension limited by 30 degrees.

union is sound, never causes any damage to the joint and results in a considerable improvement in the movements of the elbow.

In all of the fourteen cases of this injury, treated by the method described, there was displacement of the fragments. There has not been included in this series any case in which the injury caused no disturbance of the normal line of the bone. The patients' work embraced most forms of employment,—one sailor, one housewife, two engineers, two painters, one publican, five miners, one carter, and one schoolboy. With two exceptions all of these patients have been able to return to their original work without suffering any noticeable incapacity as a result of the injury.

Of the two exceptions, one patient is a painter who, in addition to the fracture of the elbow, sustained a fracture of the occipital and parietal bones with severe concussion. Following the accident, a parkinsonian syndrome developed, which interfered with the treatment and which now prevents him from climbing ladders. The result in this case was undoubtedly the worst of the series, extension being limited by 45 degrees and the last 30 degrees of full flexion being destroyed. This poor result can be easily explained by the absence of the action of gravity on the fragments during the early stages of treatment, due to the necessity for keeping the patient recumbent owing to his severe head injuries.

The other patient who has not returned to work is a collier whose elbow made a good recovery, but who is a semi-invalid suffering from disseminated sclerosis.

Although the other twelve patients have been able to return to their original work, only one has regained the full range of movements. In all the other cases, flexion and rotations are perfect, but there has been some loss of full extension. In three cases there is a loss of from 10 to 15 degrees of full extension; in six, the last 30 to 35 degrees of complete straightening of the elbow has been destroyed; and in three this movement has been limited by 45 to 60 degrees. Although the patient whose extension is limited by 60 degrees works as a painter and paper-hanger and, according to his statement, has suffered no disability, the result would undoubtedly have been more satisfactory if the mistakes mentioned earlier in the paper had not been made. In this case, after the swelling of the elbow had subsided, the limb was fixed in complete flexion for six weeks and the elbow was supported by means of a sling. One of the other two patients sustained a fracture of the external condyle of the humerus when a small boy, and extension of the elbow had ever since been limited by 45 degrees.

The number of cases reviewed for this paper is undoubtedly small, but the results show what can be done by a method so simple and so free from risks that anyone can carry it out with safety and confidence. In addition, it emphasizes once more a principle which tends to be forgotten in these days when so much dependence is placed upon evidence given by the roentgenogram,—namely, that function is of more importance than roentgenographic appearances and a perfect anatomical reduction is not necessary in order to obtain a good result.

HALLUX VALGUS

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So many people are subject to bunions and to the more serious degrees of the deformity known as hallux valgus, of which a bunion is almost invariably an accompaniment, and so gratifying are the results of both conservative and radical treatment in appropriate cases, that a few observations growing out of long experience with cases of this sort do not seem amiss. It is a common lay belief that when one has this deformity it has been caused by wearing a short shoe at some time. If by a "short shoe" is meant one in which the toes come too near the box on the shoe, this is not necessarily true. If, on the other hand, is meant a shoe in which the vamp is cut too low—that is, too near the great-toe joint—then that sort of a "short shoe" is very probably a conspicuous causative factor. Under such circumstances, the great-toe joint is so placed on the last that the leather pushes the great toe over toward the other toes as the last narrows toward the box, and, when the box is reached, its more rigid leather is even more insistent upon crowding the great toe away from the median line. Every time such an individual steps forward in his stride, he tends to thrust the forefoot into a narrowing pocket at the end of the shoe and consequently the great-toe joint and sometimes the corresponding joint of the fifth toe are chafed by the leather over these articulations.

The commonest causes for maladaptation of the foot to ready-made shoes, aside from the variations brought about through changes in the styles of footwear, are the anatomical variations in the make-up of the tarsus and the metatarsus. These changes are more common than is generally realized. The late Dr. Thomas Dwight called attention to these by pointing out that variations amounting to one-half an inch in the lengths of the first metatarsals were not at all uncommon and, where such variations occurred, they were compensated by a corresponding shortening or lengthening of the articulating phalanges.

One of the consequences of this would naturally be to place the metatarsophalangeal joints nearer to the point where the last of the ready-made shoe begins to narrow toward the tips of the toes or to push it back more nearly beneath the seam that marks the juncture of the vamp with the upper. In the first instance, this means that the great toe will be crowded over toward the outer side of the last and a hallux valgus may develop, and, in the second instance, that pressure on the dorsum of the metatarsal head may ultimately result in a hallux rigidus.

If these situations were recognized sufficiently early, there would be no crippling deformities and no necessity for surgical treatments. Insistence upon a straight inside line to the last and location of the first metatarsophalangeal joint from one-half an inch to three-fourths of an inch in front of the juncture of the vamp with the upper should avoid these

difficulties. This would mean that the great-toe joint would be at about the same distance behind the posterior edge of the box as it is in front of the vamp. If this condition cannot be met by a ready-made shoe, the need for a custom-made one is imperative.

If a beginning hallux valgus cannot be slightly overcorrected manually, the author doubts that any shoe or toe post will prevent a progression of the deformity to a state where operative correction will not be necessary. In the case of hallux rigidus it is his belief that a properly made shoe will permanently relieve all subjective symptoms and only in very exceptional circumstances will operations be in order.

When it comes to the choice of surgical measures in the treatment of hallux valgus, the writer is convinced that the simpler the procedure, the better, provided it is recognized that the deformity is not the result of any sort of an exostosis on the inner aspect of the first metatarsal head. Occasionally, there may be complicating hypertrophic arthritic changes here, and in certain severe acute infections there may be proliferative osseous lesions, as in Neisser infections. In neither of these cases, however, should operations be performed. Procedures that contemplate slicing off the inner border of the metatarsal head, or transplanting tendons to adduct the proximal phalanx, or rendering the operation more surgical by complicating an excision of the metatarsal head by an arthroplasty, or fracturing the shaft of the first metatarsal to correct abduction do not meet the anatomical conditions present in a hallux valgus, or, if they do, they do it in an unnecessarily complicated fashion.

There are no methods of attacking the problem surgically that are not open to some objections. The method devised long ago by Hueter has always appealed most strongly to the author and, unless some essential has not been performed satisfactorily, he has had no reason to regret his adherence to its fundamentals. It has been criticized most often because it has been thought that the anterior arch must be weakened by the removal of one of its abutments. Whereas this would appear to be a reasonable objection, the fact remains that, when the proper after-care has been provided, no such impairment is in evidence.

For the benefit of those to whom this problem is not presented often enough to give them a large clinical experience in dealing with it, one may perhaps be excused for emphasizing certain details of this operation of Hueter's. The first essential is the removal of enough of the metatarsal head. The skin incision should be centered over the line of the joint and should curve with its convexity toward the dorsal surface of the toe and in this convexity should lie the bursal enlargement, if there is one. The bursa should be dissected out of the skin flap, care being exercised not to "buttonhole" the skin. After the bursa has been removed, the fascia is incised to the bone (first metatarsal) and stripped back, by blunt dissection, over the entire circumference of the bone to a distance of at least one-half an inch posterior to the line of the proposed osseous incision. Then, with a saw-tooth chisel having, for the operator's comfort, a broad

head, the bone incision is made clear through from the inner aspect of the metatarsal to and through the outer cortex. The incision should be placed at about one-fourth of an inch anterior to the level where the metatarsal shaft begins to expand to form the head of that bone. Secondly, this osseous incision should be made at right angles to the long axis of the shaft of the metatarsal.

The operator should not yield to the temptation to complete the excision by fracturing this outer cortex by prying off the head. If done in this way, there will be spiculation of the end of the metatarsal, a fruitful source of painful after-symptoms. The phalanx, of course, is not disturbed. It should be obvious that this amount of bone cannot be removed from the capsule of the joint and no provision made to counteract the tendency of the phalanx to assume a position in which the horizontal plane of the plantar surface of the metatarsal and that of the phalanx are not still continuous. This is provided for in the application of the dressing after the capsule has been closed with three or four chromic catgut sutures and the skin with a continuous dermal suture.

To accomplish this, a sterilizable German-silver splint may be fashioned, so as to exert pressure upon the dorsal surface of the proximal end of the phalanx, and curved in such a way that adduction of the great toe may be accomplished at the same time. These splints may be made up in rights and lefts, requiring very little adjusting for any adult. In the absence of this splint the same object may be achieved with an unfolded gauze sponge, one end of which encircles the proximal end of the phalanx; as it is applied, the toe may be forcibly flexed and adducted, and a gauze plug should be inserted in the cleft between the great and second toes. This must be kept in place during the two to three weeks required for contraction of the capsule. In this way will be avoided the upriding of the phalanx upon the metatarsal, a situation that marks failure to attend to this detail. Weight-bearing should not be permitted for three weeks and, as a rule, it will be another three weeks before the patient can get his own shoe on and walk with reasonable comfort.

If this plan is followed conscientiously, one may predict a satisfactory result, functionally and otherwise.

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SUBASTRAGALAR DISLOCATION

A Report of Seven Cases *

BY HUGH SMITH, M.D., MEMPHIS, TENNESSEE

From the Willis C. Campbell Clinic

Subastragalar dislocation is not so rare as the total number of cases reported would lead one to assume. Shands in 1928 reviewed the literature; he found 138 cases and added one of his own, which was the first in the records of the Johns Hopkins Hospital. Of 1,089 fractures of the ankle over a period of nine years, Stimson reported only five subastragalar dislocations over a similar period of time. Straus in 1935 emphasized the infrequency of this lesion, stating that only 148 cases had been recorded in the 123 years since Judey and Dufaurest reported the first two cases in 1811.

On the assumption that the rarity of this lesion was exaggerated by a paucity of reports and that the number of cases reported was not commensurate with the actual occurrence of this lesion, 535 consecutive dislocations of all types from the Willis C. Campbell Clinic were reviewed. Seven subastragalar dislocations were found, the incidence of occurrence being 1.3 per cent. The records of the Memphis General Hospital revealed three subastragalar dislocations over a period of fifteen years, but these are not included in this report.

No age group is exempt from this dislocation. Six cases are reported in the literature in which the patients were over sixty years of age. Included in this report is the case of a child aged ten. The incidence is six times greater in males than in females, which is commensurate with the etiology,—violent trauma.

The types of dislocation may be described as inward, outward, backward, and forward. The lateral displacement of the foot is usually associated with varying degrees of posterior or anterior displacement and may be classified as external and anterior, medial and posterior, etc., but this is of more academic interest than of practical importance. Therefore the seven cases herein reported were classified as follows: medial, three cases; lateral, four cases.

One hundred fifty-five cases of subastragalar dislocations, including those herein reported, were analyzed as to the type of displacement, with the following result:

Medial	87 cases
Lateral	52 cases
Forward	6 cases
Backward	10 cases

The medial type is, therefore, more common than the combined total of the other three.

*Submitted for publication July 16, 1936.

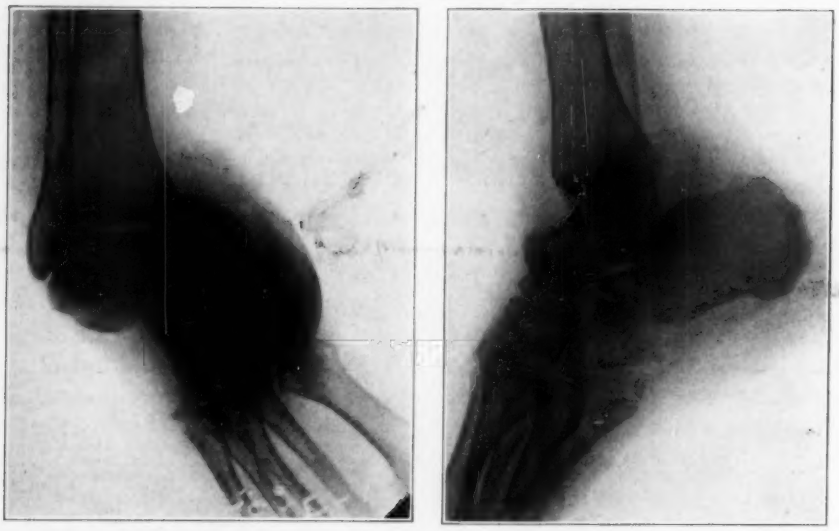

FIG. 1-A FIG. 1-B

Case 1. Medial subastragalar dislocation.

The functional relationship of the astragaloscaphoid and the astragalocalcaneal joints manifests itself in subastragalar dislocations, as there is an accompanying dislocation of the astragaloscaphoid joint.

The medial type of dislocation, which is the most common, is produced by a combined, violent plantar flexion, adduction, and supination of the foot, while the astragalus is carried forward and laterally by a force acting through the tibia and the fibula. The joint capsule and the dorsal astragaloscaphoid ligaments are torn, and the head of the astragalus is displaced upward and laterally from its articulation with the scaphoid, as the astragalocalcaneal ligaments are ruptured and the os calcis is displaced medially. The head of the astragalus rests upon the cuboid or upon the articulation between the cuboid and the scaphoid. If the force is extreme, the os calcis, the cuboid, and the scaphoid may be medial to the internal malleolus.

In the lateral type the dislocation is produced by abduction and pronation. The tibioscaphoid and calcaneoscaphoid ligaments and the joint capsule are ruptured with medial and forward displacement of the astragalus and lateral displacement of the remaining tarsal bones after rupture of the astragalocalcaneal ligaments. The head of the astragalus lies parallel with and overlaps the medial side of the scaphoid.

Complete relaxation is a necessary prerequisite to successful closed manipulations. Briefly, reduction may be accomplished by exaggerating the existing deformity, and then reversing the forces which produce the dislocation with traction on the foot and direct pressure on the head of the astragalus. The knee is flexed to relax the tendo achillis. A normal contour is restored with an audible snap.

In cases of extreme lateral or medial displacement, numerous attempts at closed manipulation may fail. The extensor tendons to the toes, the posterior and anterior tibialis tendons, and the capsule or ligaments adjacent to the astragaloscaphoid joint may become looped over the head and neck of the astragalus in such a manner as to prevent reduction. After proper exposure and incision of these structures, reduction is easily accomplished. This was true in two of the five fresh cases of this series.

Old unreduced dislocations require a complete reconstruction of the tarsal joints. In Case 7 the scaphoid and the head of the astragalus were removed with arthrodesis of the subastragalar and calcaneocuboid joints and the remaining portion of the astragalus to the cuneiforms, with an excellent functional result.

CASE REPORTS

CASE 1. A white woman, aged forty-nine, was struck by an automobile and sustained an injury to her right ankle. Roentgenograms (Figs. 1-A and 1-B) revealed a medial subastragalar dislocation with a fracture of the fifth metatarsal bone. Closed manipulation was unsuccessful. A large mass of ligamentous tissue was found to be looped over the lateral side of the head of the astragalus in such a manner as to prevent reduction. Reduction was easily accomplished after removal of this obstruction. (See Figures 2-A and 2-B.) An excellent functional result was obtained.

CASE 2. A white woman, aged thirty-five, injured her right ankle in an automobile accident. Examination showed a lateral subastragalar dislocation (Figs. 3-A, 3-B, and 3-C). At operation the head of the astragalus was displaced across the tibioscaphoid and calcaneoscaphoid ligaments. Following immobilization in a boot cast for four weeks (Figs. 4-A, 4-B, and 4-C), extensive physical therapy was instituted. Four months later the range of motion in the foot and ankle was practically normal.

FIG. 2-A

FIG. 2-B

Case 1. After reduction.

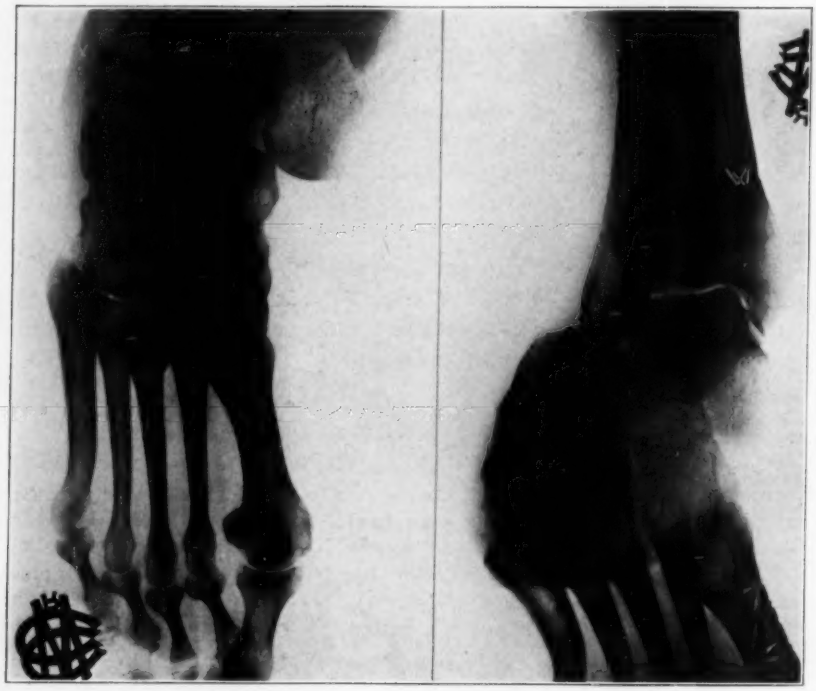

FIG. 3-A FIG. 3-B

Case 2. Lateral subastragalar dislocation with marked forward displacement of foot.

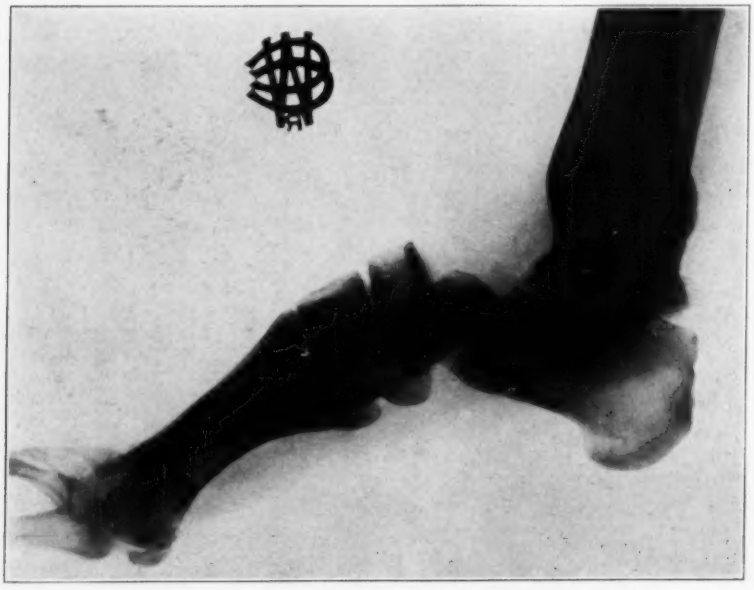

FIG. 3-C

Case 2. Lateral view, showing subastragalar dislocation.

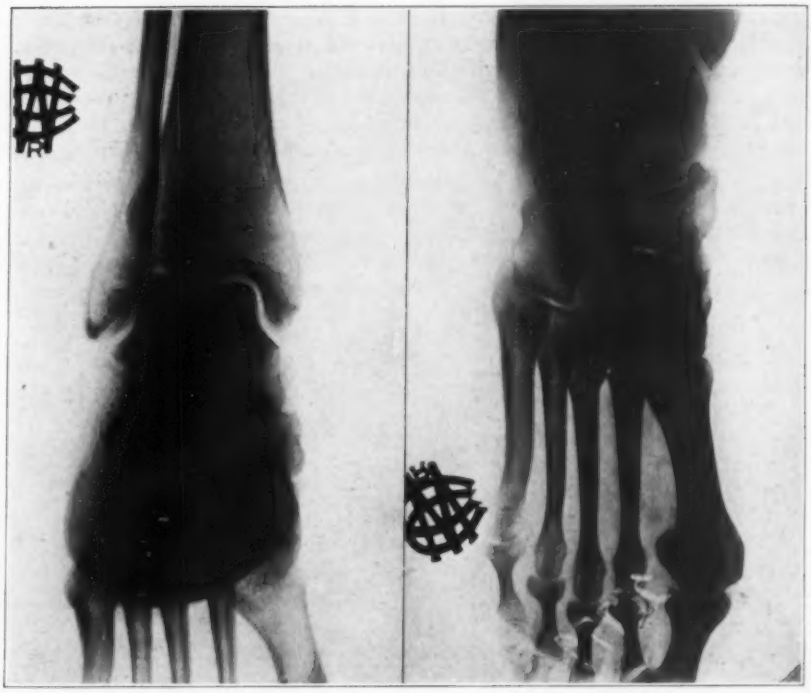

FIG. 4-A FIG. 4-B

Case 2. After reduction.

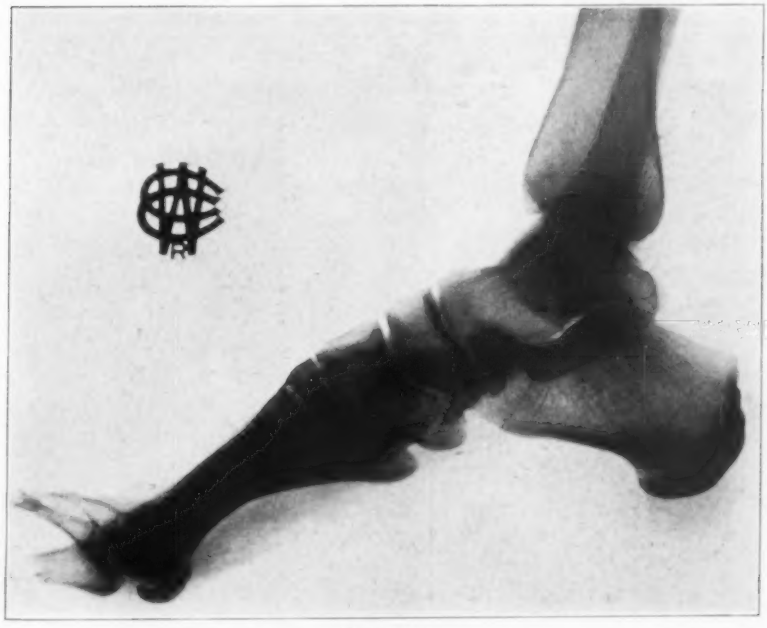

FIG. 4-C

Case 2. Lateral view after reduction.

CASE 3. A white woman, aged thirty-two, was admitted with the left foot in marked supination and the forefoot at a right angle to the anterior posterior plane. The astragalus was protuberant laterally. (See Figures 5-A and 5-B.) The injury was the result of an automobile accident. This medial subastragalar dislocation was reduced by closed manipulation. (See Figures 6-A and 6-B.) Five months later function was excellent except for slight limitation of motion in abduction and adduction.

CASE 4. A white man (age not recorded) was seen in consultation for a severe in-

FIG. 5-A

FIG. 5-B

Case 3. Medial subastragalar dislocation with foot at right angle to normal position.

FIG. 6-A

FIG. 6-B

Case 3. After reduction.

jury to his right foot, received while working in an elevator shaft. Roentgenograms revealed lateral displacement of the tarsal bones at the subastragalar joint; the astragalus was in its normal relationship with the tibia. There was a chip fracture of the external malleolus, as well as a fracture of the neck of the os calcis with slight displacement, and a line through the posterior surface of the astragalus suggested a fracture without displacement. The end result is unknown.

CASE 5. A white man, aged twenty-five, had injured his foot and ankle fifteen years previous to admission, when a horse had fallen on him. After long hikes while in the Army he had had marked pain and swelling. At examination, the foot was found to be cyanotic with marked limitation of motion in all directions. There was lateral displacement of the foot at the subastragalar joint, and the patient stood with the foot in moderate pronation. A subastragalar fusion was advised, but refused.

CASE 6. A white man, aged forty, sustained an injury to his foot when a porch fell. He did not know whether the injury was due to falling material or to his own weight.

FIG. 7-A

FIG. 7-B

Case 7. Old reduced lateral subastragalar dislocation.

FIG. 8-A

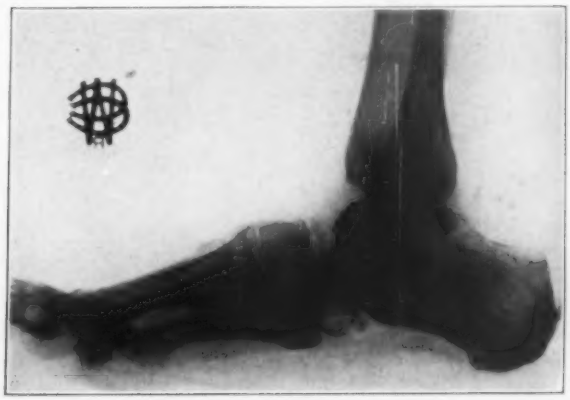

FIG. 8-B

Case 7. After reconstruction and arthrodesis.

There was a medial subastragalar dislocation with a fracture of the head of the astragalus, the loose fragment being displaced upward. The foot was forcibly reduced without difficulty. The end result is unknown.

CASE 7. A white man, aged fifty-two, jumped from a bale of cotton and injured his right ankle. No roentgenograms were made, and the ankle was immobilized in a splint for six weeks. When first observed (Figs. 7-A and 7-B) this lateral subastragalar dislocation was of six months' duration. A triple arthrodesis and reconstruction operation were done. (See Figures 8-A and 8-B.) Recently, after six years, the patient has again been observed. His weight is 300 pounds and he walks all day without symptoms.

SUMMARY AND CONCLUSIONS

In a review of 535 dislocations, seven subastragalar dislocations were found, the incidence of occurrence being 1.3 per cent. It was found that with prompt reduction good functional results could be anticipated. No difference in end results was noted between the cases in which closed reduction was done and those in which reduction was obtained by open operation, although convalescence was somewhat prolonged in the latter cases. Of the seven subastragalar dislocations, an excellent result was obtained in four; the end result in the other three cases is unknown.

Associated fractures of the tarsal and metatarsal bones and of the tibia or fibula, which are common, may complicate treatment and produce permanent disability. A permanent limitation of abduction and adduction of greater or lesser degree may be expected after such violent trauma. Old unreduced dislocations require complete tarsal reconstruction and arthrodesis.

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INJURIES TO THE ACCESSORY PROCESSES OF THE SPINAL VERTEBRAE *

BY MERRILL COLEMAN MENSOR, M.D., SAN FRANCISCO, CALIFORNIA

The successful treatment of low-back pain resulting from trauma depends primarily upon our knowledge of what anatomical structures have been damaged and our recognition of the extent of this damage.

This presentation does not deal with compression fractures, but has for its purpose a discussion of fractures of those accessory processes of the vertebra which constitute the pedicles, the lamina, and the articular facets. Injuries to the lamina, the pedicles, and the articular facets are only discernible by special roentgenographic studies, made at various angles, and are rarely seen in the routine anteroposterior or lateral views.

Although from time to time some mention has been made of fractures involving this area, the paucity of literature on the subject would apparently indicate that these injuries have not received what seems to us due consideration in our routine examinations. It is our belief that these fractures frequently follow torsion injuries and that they give rise to prolonged low-back symptoms.

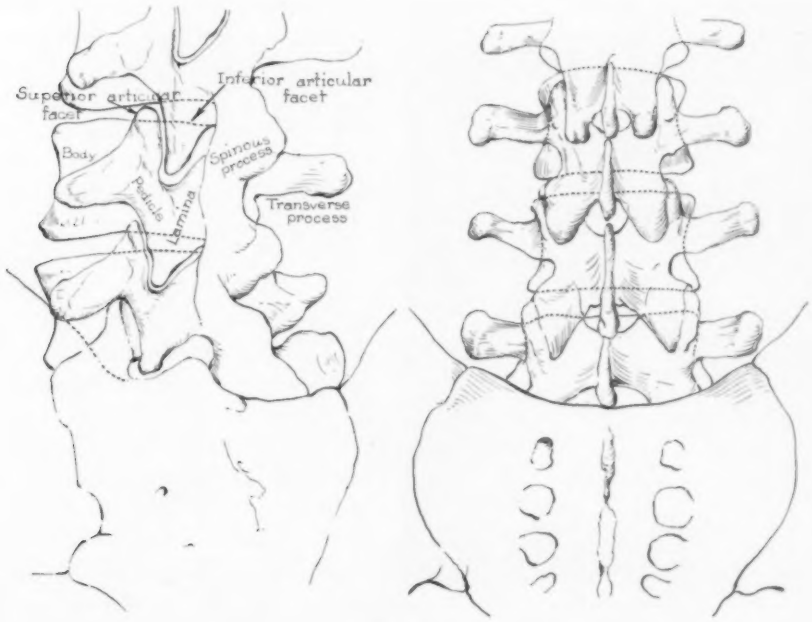

FIG. 1

Tracing of roentgenogram of normal lumbar spine, showing an oblique study and the routine anteroposterior view of the same area.

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Cleveland, Ohio, January 12, 1937.

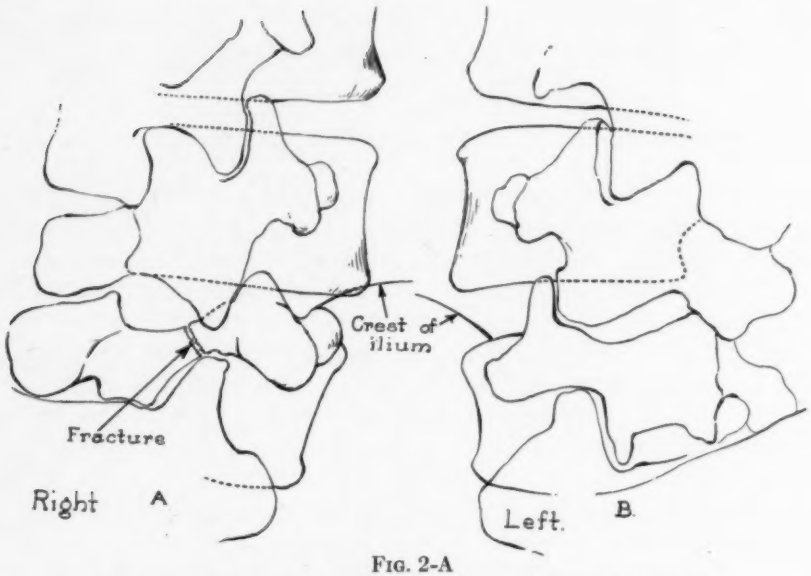

FIG. 2-A

A: Torsion injury with fracture through the base of the lamina.
B: Left oblique view, showing normal bone continuity for comparison.

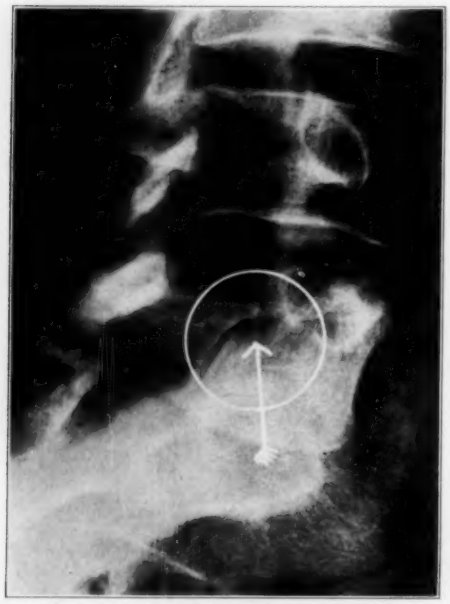

FIG. 2-B

Reproduction of original roentgenogram. Note the irregularity and the extent of the fracture line.

During the past five years a study of several hundred patients with low-back pain following trauma has led us to believe that fractures of the accessory processes occur both alone and with compression fractures of the vertebral body. We hope with the aid of our illustrations to demonstrate clearly that our opinion concerning the existence and frequency of these fractures is not based on purely theoretical grounds.

It is our belief that torsion plays a prominent part in all injuries to the low back, either acting as a primary force or combined with flexion or hyperextension. That such torsion may well produce injuries to the accessory processes does not seem to us unlikely. The results of torsion stresses on long bones are well recognized. The same type of force acting on the spinal column through the mechanism of a long lever—the

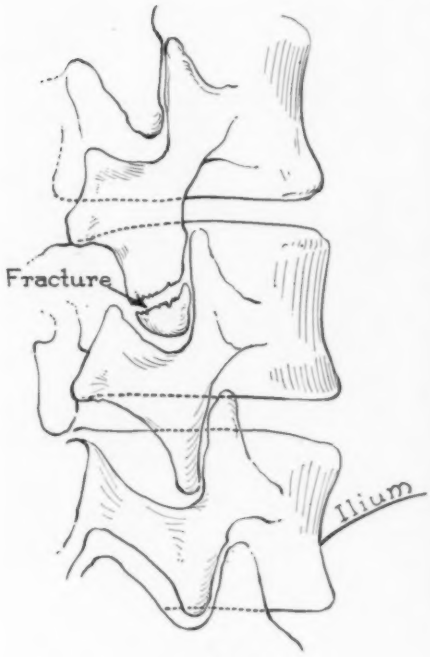

FIG. 3-A

FIG. 3-B

Torsion injury followed by fracture of the inferior articular facet of a lumbar vertebra. Note the irregularity of the fracture line with the rotation and displacement of the caudal fragment.

spine and the upper extremities—and a short fulcrum—restricted to the small area of the lamina, the pedicles, and the articular facets—could well exert sufficient force to cause fracture. Depending upon the amount and location of the force exerted, it seems rational that there will result either ligamentous or bony injury similar to that occurring in the extremities. (Examples of fractures caused in this manner are illustrated in Figures 2-A through 5-B.)

We have found fractures of the articular process complicating compression fractures of the vertebra and this may explain the cause of persistent low-back pain found in some patients in spite of perfect anatomical restitution of the gross deformity of the body. (See Figure 6.)

There is no clinical index for the amount of trauma that may be involved in this torsion mechanism, but, as a result of our experience, in cases of severe back strain with persistent localized symptoms, special oblique roentgenograms have shown a surprisingly high percentage of fractures of the accessory processes. We believe the frequency is sufficiently great to warrant the addition of oblique roentgenographic studies as a routine method of diagnosis in any case following trauma in which roentgenograms of the spine are indicated.

Although we would not presume to give accurate statistical data relative to the frequency of these lesions, we have found with our accumu-

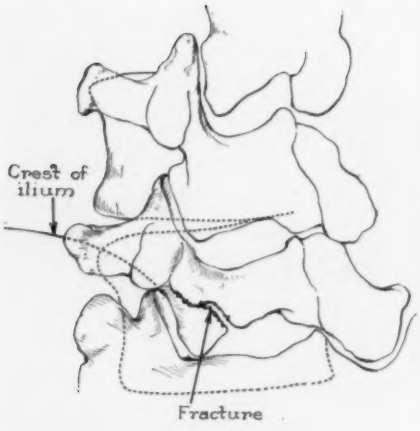

FIG. 4-A

Torsion injury, causing irregular fracture extending from the lamina into the isthmus and the base of the articular facet.

FIG. 4-B

lating experience, as our procedure in taking oblique roentgenograms has changed from the occasional case to an increasing number of complete studies, that the percentage of fractures has become noticeably higher.

As a majority of these injuries are found in ambulatory patients presenting symptoms of acute low-back disability following torsion

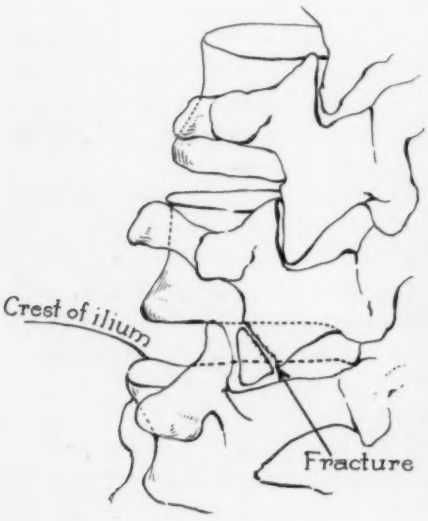

FIG. 5-A

FIG. 5-B

Torsion injury with fracture of the inferior articular facet of the lumbar spine. Note the irregularity and the course of the fracture line, the sharp, clear-cut edges, and the displacement of the fragment toward the opposing articular surface.

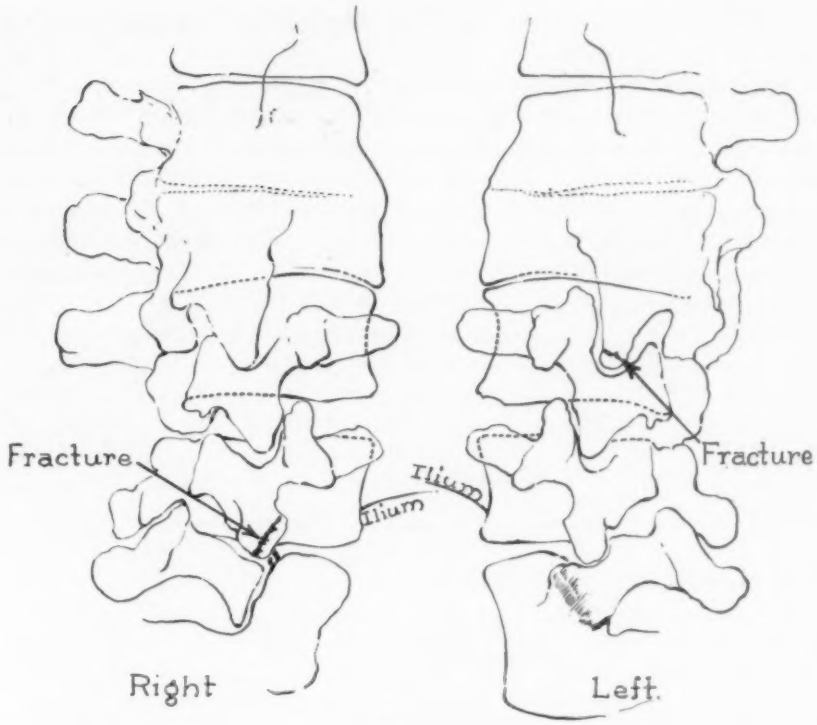

FIG. 6

Tracing of roentgenogram, showing compression fracture of the lumbar spine with fracture of the inferior articular facet in the vertebra below on the left side. Continuation of the torsion force has caused fracture of the base of the pedicle on the opposite side at a lower level.

injuries, some idea of the frequency of their occurrence may be ascertained by the following figures taken from our office records during the past two years. Roentgenographic examination of the low back following injury was deemed necessary in 141 patients; in these cases, sixty-seven oblique studies (approximately 50 per cent.) were made. Twenty-two, or approximately 33 per cent., of these oblique studies showed fractures involving the accessory processes under discussion. There were nine cases (13 per cent.) of anomalies involving the lamina, the pedicle, and the articular facets. The frequency of fractures in these specific accessory processes was about two and a half times greater than the frequency of anomalies.

The difficulty in the recognition of these fractures has been due primarily to lack of development of a proper routine roentgenographic technique for visual demonstration of fractures in these processes. Visualization of such a fracture is only possible by taking roentgenograms at various angles, depending upon the anatomical peculiarities of the particular spine under observation. The essential point is to project the articular facets, the pedicles, and the lamina in detail, in order that minor

abnormalities may be recognized. Stereoscopic studies are of material assistance in this respect.

The roentgenographic technique is simple but time-consuming. Patients with these lesions are uncomfortable in oblique positions and require careful immobilization, as the roentgenograms with fine focus tubes require a relatively long exposure. The planes of the facets of the vertebral articulations are variable in individuals and in different vertebrae and are frequently asymmetrical in the same vertebrae, so that no routine angle of rotation could be satisfactory. A trial oblique study at 45 degrees can be used as a base line, followed by further studies with either an increase or a decrease in angulation until all of the affected accessory processes are visualized.

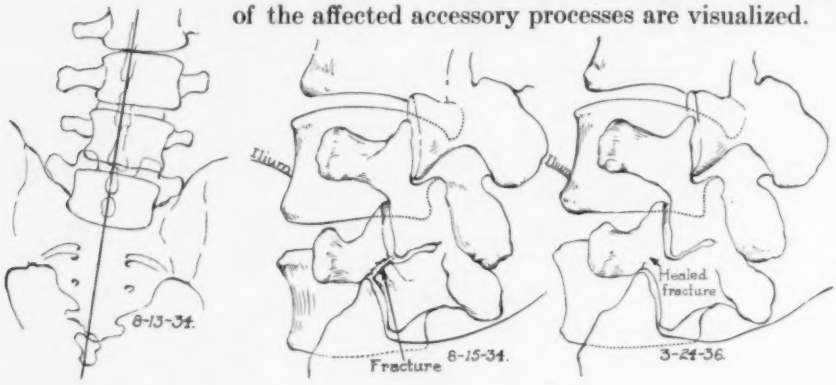

FIG. 7-A

Tracings from roentgenograms of a torsion injury, showing fracture through the isthmus and healing of the fracture one and one-half years later. Note the list of the spine toward the lesion, resulting from trauma to the lateral articulation.

FIG. 7-B

Roentgenogram, August 15, 1934.

FIG. 7-C

Roentgenogram, March 24, 1936.

In the interpretation of these films there comes to mind at once the frequency of the common congenital anomalies and failures of ossification in this area and one must be able to differentiate between these conditions and true fractures.

The common anomalies are seen as defects in the articular facets and failure of fusion of the lamina and the pedicle. These anomalies and fractures may occur in analogous locations. Anomalies can be differentiated by their clear-cut line of cleavage, the smooth, rounded character of the bone edges, and the sclerotic changes at the periphery of the fragments. In contrast to these findings, fracture lines are irregular, in variable planes depending upon the lines of force. They frequently show varying amounts of displacement and rotation of fragments when studied stereoscopically. These fractures followed over a given period will disclose evidence of bone regeneration, in many cases progressing to complete healing as illustrated in Figures 7-A, 7-B, and 7-C; whereas anomalies are stationary without visible change over a similar period.

Early recognition of fractures in this area is important both from the standpoint of differential diagnosis, of treatment, and of prognosis. Early treatment, consisting of moderate ambulatory immobilization over a sufficient period for the promulgation of bony union, offers an excellent prognosis for complete recovery.

The type of immobilization used can be left to the discretion of the attending surgeon, if he bears in mind the following principles: (1) the elimination of large arcs of motion in the affected area and the prevention of torsion and rotation movements; and (2) the preservation of the patient's normal postural curves and the tonicity of his spinal musculature. Braces of light spring steel of the Brackett type and, in some cases, light non-padded plaster jackets have proved quite efficient.

In contrast to the results following early diagnosis and initiation of treatment, undiagnosed, untreated lesions give a relatively high percentage of non-union. Such untreated cases, seen months after the injury, frequently show the fracture ends eburnated and smooth, with evidence of a typical non-union, and having a roentgenographic appearance practically analogous to an anomaly. In such cases it is often impossible to make a differential diagnosis. This roentgenographic appearance may be due to excessive mobility at the fracture site, to peculiarities of the local vascular supply, or to a combination of both. Some pertinent comparisons can be drawn in fractures of the ulna styloid and the carpal scaphoid. The presence of non-union in many cases is a cause of persistent pain. Similar symptoms may also result from a fracture of the articular facet, which has healed with displacement, setting up sufficient joint irritation to develop a traumatic arthritis.

For the permanent alleviation of symptoms in cases of non-union or of malunited articular fractures surgery seems indicated. In some instances a facetectomy will suffice, while others require spinal fusion. However, our experience in this phase of the treatment is too limited at present to draw any positive conclusions.

CONCLUSIONS

1. More complete roentgenographic studies of the spine, made in various planes, will reveal previously undiagnosed fractures of the accessory processes as one of the causes of previously unexplained chronic low-back pain following injury.

2. Early diagnosis, which is only possible by complete roentgenographic examination, and the institution of adequate conservative treatment give an excellent prognosis for complete recovery in simple lesions.

3. Injuries resulting in permanent damage to the articular facets may require surgery for their alleviation.

4. In debatable injuries, early studies with systematic follow-up will demonstrate fractures progressing to complete healing or to sclerotic changes, in contrast to anomalies which are unchanged over a similar period.

5. This study has proved to our satisfaction that fractures of the articular processes are of relatively frequent occurrence and we hope by this presentation to have stimulated sufficient interest for more careful routine investigation of these portions of the vertebral column.

We would not feel this paper to be complete without an expression of appreciation to several of our local colleagues for their interest and cooperation, especially to Dr. Frederick H. Rodenbaugh whose excellent roentgenographic technique has made this presentation possible.

THE PHYSIOLOGICAL METHOD OF TENDON TRANSPLANTATION IN THE TREATMENT OF PARALYTIC DROP-FOOT *

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Just twenty years ago Biesalski and Mayer published their work on the physiological method of tendon transplantation. Although a complete review of the developments of the twenty years is impossible in the confines of this paper, it seems to the author worth while to attempt an evaluation of the treatment of one type of paralytic deformity—drop-foot—by means of tendon transplantation. The cardinal principles of tendon transplantation which were laid down twenty years ago still hold good. These are briefly:

1. Whenever possible retain the normal relationship between the transplanted tendon and the gliding apparatus.

2. Operate with minimal trauma, avoiding injury to the sheath, to the paratenon, and to the delicate gliding cells on the surface of the tendon either by improper handling with instruments, or by undue exposure to the air, or by contact with gauze.

3. Establish adequate mechanical lines of traction, so that the transplanted tendon may be able mechanically to do what is expected of it.

These principles have become so much a part of modern tendon surgery that few surgeons realize their indebtedness to Biesalski who was the first orthopaedic surgeon to utilize the sheath of the paralyzed tendon as a physiological pathway for the transplanted tendon. The development of tendon surgery to its present adequate technique is due largely to this physiological concept worked out by Biesalski.

Of the practical developments since the Biesalski-Mayer publication, the most important in the correction of paralytic foot deformities has been the association of tendon operations with bone stabilization. For five years the author struggled vainly to obtain permanent correction of paralyzed feet by tendon transplantation alone. Then, in 1921, Hoke published his method of stabilization and, through Gill's discussion of this paper, the writer's attention was drawn to the similar operation of G. G. Davis. Thereafter, by combining bone stabilization with the physiological method of tendon transplantation, the problem of securing permanent correction was solved.

Not all cases of drop-foot can be treated by this combined method. Those in which the peroneal tendons, as well as the dorsiflexors, are paralyzed are best treated by the Campbell bone block or by its modifications. In a few instances, the author has supplemented the bone block by trans-

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planting the tibialis posterior to the outer border of the foot. This operation, originally described by Biesalski and Mayer, is far less likely to succeed than is the use of peroneal transplants, since the tibialis posterior has to wend a somewhat circuitous course over the mesial surface of the tibia. This not only makes adhesions more probable, but the curving line of traction interferes with strong dorsiflexor action. Despite this obvious disadvantage, both Ober and the writer have secured some excellent results, but in the author's opinion it is not wise to rely upon the tibialis posterior alone to counteract the plantar flexors. This procedure should be used to supplement the Campbell bone block. Putti, in a personal communication, reports the transplantation of the tibialis posterior through the interosseous membrane. To prevent adhesions, he cuts a large window in the membrane. The writer has had no experience with this method, which, he must confess, seems at variance with his observations of tendon physiology.

When both peroneal muscles are present, they can be converted into such powerful dorsiflexors that the posterior bone block is not necessary. Some operators, notably Freiberg, transplant only the peroneus longus. Although this muscle can unquestionably produce dorsiflexion, the balance of power would remain strongly in favor of the plantar flexors. A muscle balance more nearly comparable with the normal can be secured only by utilizing both peronei. This will subtract from their everting power and a varus would result were the tendon transplants not supplemented by an arthrodesis of the subastragalar joint. A particularly instructive case in this respect was a traumatic drop foot which the author operated on in 1920. The patient, a child of five years, was run over by a reaping machine which severed all the dorsiflexors. Infection followed with extensive destruction of the tendons. Since the muscles themselves were undamaged, the dorsal tendons were reconstructed by means of three free tendon grafts. For this purpose, the peroneus longus tendon was sacrificed. Excellent dorsiflexion resulted, but a year after the operation a mild varus developed, evidently due to the muscle imbalance caused by the loss of the peroneus longus. If the subastragalar joint had been arthrodesed, this deformity would probably not have occurred.

In reaching a conclusion as to the operative indication for transplantation of both peronei, a number of factors must be considered. The first of these is the accurate determination of the muscle strength of the two peronei. The Lovett spring-balance test will tell us a great deal about the everting strength of the muscles, but it does not differentiate between the peroneus longus and the peroneus brevis. Electrical stimulation of each muscle will give some information, but the writer has learned to rely chiefly on palpation of the muscle bellies during the act of contraction against resistance. By far the best operative results are secured when both muscles can be felt to contract powerfully. Unless this action is sufficiently strong to overcome a resistance of several pounds, the author does not favor the transplantation.

The second factor is the age of the patient. Until 1921, it was the writer's rule to operate as soon as the patient was old enough to cooperate intelligently in the after-treatment. After Hoke published his stabilization operation in 1921, and after this operation had been made an integral part of the therapeutic program, the author did not operate until the roentgenogram showed advanced bone development of the tarsus, usually at about the tenth year. Since 1932, following Milgram's observation in Steindler's Clinic, the writer has again operated at an earlier age and some of the most gratifying results in his series have been in children as young as six years.

In operating on these younger individuals, it is important that additional bone be taken from the tibia, so as to fill out the space between the tarsal bones after the removal of the cartilage, and that minimal resections be performed to avoid undue growth disturbance.

The third factor to be considered in the operative indications is the length of time which has elapsed since the acute onset of the poliomyelitis. According to an old rule, at least two years should elapse before any operative treatment is undertaken. Although in general this rule should not be discarded, it must be subjected to frequent exception. The author has seen cases in which the operation was indicated even a year after the onset of the paralysis. These were instances in which very effective treatment had been given during the entire period without the least return of power in the dorsiflexors and with increasing equinus deformity, due to the marked imbalance between the dorsiflexors and the plantar flexors. On the other hand, the writer has seen cases in which the operation was advised against, although five or six years had elapsed, because there was no record of thorough treatment. If even a faint trace of strength is discernible in the dorsiflexors, irrespective of the length of time since the acute onset of the disease, the foot should be immobilized in a position of maximum dorsiflexion, and the weakened dorsiflexors should be given electrical stimulation through a window cut in the plaster. In a surprisingly large percentage of cases this method of treatment has successfully brought a return of strength in the dorsiflexors, thus rendering the operation unnecessary. It is only when thorough postural treatment, combined with expert electrical stimulation and muscle training, has failed that operative correction is indicated. Therefore, the exact length of time elapsing between the onset of the disease and the date of the operation is of much less significance than the nature of the treatment which the patient has received. In no case, however, has the writer operated until at least one year of efficient treatment has been given.

In describing the operative technique, it is unnecessary to repeat all the details, since these have been given in numerous other publications. Certain points should, however, be emphasized. The stabilization of the tarsal bones should always be done before the tendon transplantation. For a number of years the author performed the bone operation several weeks before the tendon operation, allowing the first operative wound to

heal completely before doing the second step. In recent years, with increasing experience, he has been able to combine the two operations into one, but he always follows the rule of doing the bone work first. This permits complete correction of the deformity and enables the operator to gage the tension of the tendon more satisfactorily. The second point is the question of lengthening the Achilles tendon. This, like the tendon transplantation, should not be attempted until the bone operation has been completed, for in many instances the Achilles tendon, which at the time of examination seemed decidedly too short, will be found approximately the right length after the stabilization has been completed. However, if adequate dorsiflexion is not possible, the Achilles tendon should be lengthened sufficiently to permit dorsiflexion to 90 degrees. Of the numerous methods which are possible, the writer prefers the hemidivision of the tendon in different horizontal planes,—the middle section cutting the deep surface of the tendon and the upper and lower sections cutting its superficial half. The operation can be done subcutaneously as well as by the open method.

When the tendons are transplanted, the peroneus longus is run through a subfascial course to the upper pole of the sheath of the tibialis anterior, then downward through the sheath to the insertion of the tendon of the tibialis anterior. To facilitate its course, a guide suture is passed through the sheath and then upward from the pole of the sheath across to the anterior intermuscular septum. The line of this guide suture must be a straight one and must be such that, were the silk fastened to the insertion of the tibialis anterior, a strong dorsiflexion and inversion of the foot would occur. By running the tendon through the sheath of the tibialis anterior, it is possible to conserve the normal gliding mechanism of the paralyzed tendon and to utilize it for the transplanted tendon.

For the peroneus brevis the intrasheath course is not advisable, since, if the tendon were drawn through the sheath of the extensor digitorum longus, it would have to run a zig-zag course which would greatly interfere with its free gliding. It is, therefore, wiser to run the peroneus brevis through the subcutaneous fatty tissues. It is attached directly to the bone by drilling a hole through the fourth metatarsal at its proximal extremity. The drill passes through the bone to the plantar surface of the foot; a small nick is made in the skin and, through this channel, the tendon is drawn by means of a chromic suture threaded on a long, straight needle. This needle is then reinserted into the plantar wound and made to appear on the lateral aspect of the foot near the lower extremity of the original incision. The chromic suture may then be fastened securely on the dorsum of the foot, thus avoiding any knot in the more sensitive plantar region.

To facilitate the passage of the peroneus longus from the lateral compartment of the muscle to the anterior, the author still follows the original method of everting the deep surface of the fascia of the lateral and anterior compartments. These deep surfaces are coated with paratenon,

or gliding tissue, and, when united by a very fine silk stitch, they form a perfect physiological bridge over which the peroneus longus tendon can glide from its original situation into the anterior compartment of the muscle. The execution of this step of the operation requires about four minutes and is, in the writer's opinion, thoroughly justified by the results.

Some operators use a subcutaneous pathway for both tendons. Frequently they get good gliding of the transplanted tendon if their technique is sufficiently atraumatic. They lose, however, the leverage action and controlled angle of application of force afforded by the annular ligament of the ankle and the advantage afforded by the normal gliding mechanism of the sheath of the tibialis anterior.

In determining the tension under which to fasten the tendons, the operator should be guided by the physiological fact that, when the foot is held in such a position as to approximate the origin of the muscle and its new insertion, the tendon should run in a straight line without any tension whatever. The operator, therefore, need only pull on the transplanted tendon with sufficient strength to make its course a straight one. Excessive tension is bad for the muscle fibers, since it subjects them to undue strain. Less tension than the normal is also bad because the tendon is then slack and the muscle belly shortens, with corresponding loss of power.

The author's experience in the after-treatment of these cases has been most instructive. Originally it was feared that a lengthy period of immobilization would cause adhesions to develop in the course of the transplanted tendon and, therefore, mobilization for three weeks after the operation was advocated. This invariably caused excellent gliding of the transplanted tendon, but, in a number of instances, resulted in displacement of the tarsal bones. For this reason the period of immobilization was prolonged and, to the writer's surprise, he discovered that a foot could be kept immobilized for six or eight weeks without the development of adhesions to the tendons which had been operated upon. At the present time, the routine is to change the original plaster-of-Paris three weeks after the operation and then to apply a second cast which is left on for four or five weeks, depending upon the age of the patient. In the second plaster a window is cut over the transplanted peronei, so that electrical stimulation of these muscles may be begun four weeks after the date of the operation.

When the plaster is removed, a light brace is applied with a catch to prevent drop-foot. The patient is given exercises and electrical stimulation to the transplanted peronei.

Despite the fact that, at the joint meeting of the British and the American Orthopaedic Associations in 1929, a prominent English surgeon stated he never had seen a transplanted tendon perform an action physiologically opposed to its original function, the author's patients have, without exception, learned to use their peronei as dorsiflexors. In fact, the action of the transplanted tendons was in one case so powerful that it

produced a calcaneus deformity. This overcorrection of the original deformity was probably due to excessive lengthening of the Achilles tendon, as it was promptly cured by reefing the elongated tendon. It emphasizes the powerful dorsiflexor action of the transplanted peronei and the necessity for accurate preoperative tests of muscle strength.

In three instances in his series of peroneal transplants, the writer has had occasion to perform secondary operations to correct minor abnormalities of the foot, such as hallux valgus. At the time of these secondary operations permission was given by the patients to inspect the transplanted peroneus longus tendon through a small incision. In all three cases the attachment of the tendon to the bone so closely resembled that of a normal tendon that it could not be distinguished from the normal. In one case the author was allowed to remove a small specimen of tendon with the bone to which it was attached. When examined microscopically, this showed a transition of tendon to bone, corresponding exactly with the normal. When the muscle was stimulated electrically, within the sheath of the tibialis anterior the peroneal tendon could be seen to glide to and fro with approximately normal range of motion. The peroneal tendon had apparently fused within the sheath with the tibialis anterior, for only one tendon was distinctly visible. There were no adhesions between the tendon and the lining wall of the sheath.

SUMMARY

Twenty years of experience in the treatment of paralytic drop-foot by means of the physiological tendon transplantation, combined with stabilization of the ankle, have convinced the author of the efficacy of this method in the correction of this type of paralytic deformity. The actual examination of the tendons at secondary operations, as well as by clinical tests, shows that transplanted tendons can function with almost the same strength and freedom of motion as normal tendons, provided that the physiological method of transplantation is followed.

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TUBERCULOUS PERICHONDRITIS AND PERIOSTITIS OF THE RIBS

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During the past fifteen years of experience with more than fifty cases of chondromyelitis of a typhoid and paratyphoid character, cases of tuberculous perichondritis were not infrequently met with, and, from 1921 to 1933, fourteen cases in which the diagnosis was definitely determined came under observation. Of this number, ten were treated surgically and four conservatively. The ten cases were operated on in different stages of the disease, and, by examination of the resected cartilage and ribs, it was possible to observe the different stages of the pathological process and, with a reasonable degree of certainty, to draw conclusions as to the undetermined question of whether cartilage with its perichondrium and the rib with its periosteum become involved primarily, or whether the tuberculous focus appears in the surrounding soft tissues and the rib becomes involved secondarily. Some authors hold the opinion that lesions in the cartilage have their origin in the perichondrium; others (Hayem, Lediberder, Lannelongue, Poloson, Alglave, Sorrel, and Mouchet) have observed cases of primary tuberculous chondritis. Dujarier observed in a sixteen-year-old girl an abscess of the chest which he considered unquestionably to be of cartilaginous origin.

However, many modern authors who are interested in the subject of surgical tuberculosis incline to the view that the cartilage and the rib become involved secondarily. Kisch considers primary infection of the cartilage doubtful inasmuch as tuberculous infection is originally embolic, whereas the "hyaline cartilage, at any rate in youth, does not have vessels". The opinion that blood vessels are absent in the rib cartilage cannot be substantiated at the present time, especially since the works of Russian authors (Linberg, Petrov) in connection with typhoid chondritis.

In the histological examination of rib cartilage in young individuals who had died from various causes, carried out in the laboratory of Prof. Yelenevski, the author was able to demonstrate that in youthful subjects not only are blood vessels present, but also elements of the so called cartilage marrow are copiously vascularized. It, therefore, follows that, although the blood vessels may be absent, this cannot be used as an argument against primary chondritis. The typhoid and paratyphoid lesions demonstrated during operation and on pathological preparations that the cartilage is primarily affected, and that the vessels, together with the cartilage marrow, have a very definite significance.

In the case of tuberculous infection it would seem that the relative significance lies not in the vascularization, but in other factors which

FIG. 1

Specimen showing paratyphoid chondritis. Intracartilaginous abscess on the line of demarcation between bone and cartilage.

will be discussed. Recently Iselin has given his opinion that cold abscesses of the thoracic wall are usually the result of tuberculous pleurisy, of tuberculosis of the lungs, or of tuberculosis of the mediastinal lymphatic glands. Although this does not solve the question of the primary localization of the tuberculous focus, it does endorse the observation which the author has made during operations and also the opinion of Pereshivkin that the suppuration of the peripleuritic glands is an etiological factor in peripleurisy.

In a series of operations for tuberculous perichondritis, and in more than forty cases of infectious chondritis, there was noted a significant difference in the pathological anatomical changes of the cartilages in the two processes. In infectious chondritis there was nearly always found a cavity in communication with the surface by either a large or a small opening, and in one case of an early resection there was found a cystic focus in close proximity to the line of demarcation between the opening and the cartilage. (See Figures 1 and 2.) This is significant with respect to the influence of primary lesions of the cartilage in infectious chondritis. This localization of the focus tallies with the localization in cases of osteomyelitis.

In cases of tuberculous lesions of the cartilage of the rib, the cavities in the cartilage or in the rib were not found; on the other hand, the lesion was a surface ulcer of greater or of lesser extent. (See Figures 3 and 4.) Frequently there was found a cavity of appreciable size located beside the pleura and under a slight lesion of the cartilage or of the rib, and the changes in the adjacent soft tissues were always more noticeable than in the rib or in the cartilage.

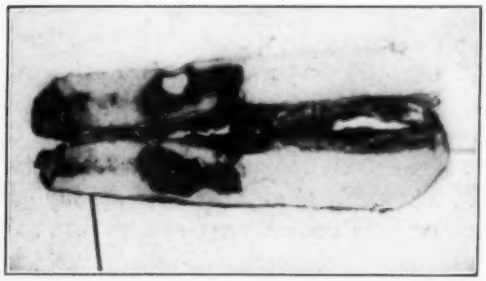

FIG. 2

Specimen showing paratyphoid chondritis. Intracartilaginous abscess on a lesion of the cartilage.

The absence of isolated rib lesions, the limitation of the destruction in nearly all cases to the pleural surface of the cartilage, and the discrepancy between the appreciable peripleural abscess and the slight

lesion of the cartilage led the writer to believe that in many cases there existed a lesion of the lymphatic glands, following which secondary changes appeared on the surface of the cartilage. This opinion is to a very significant degree supported by the following case of an early rib lesion.

CASE 1. K. A., aged twenty-four, on March 29, 1923, presented a swelling in the region of the left fifth, sixth, and seventh ribs between the mammillary and midaxillary lines. This swelling was irregular in outline, immovable, and not sensitive, and there were no cutaneous changes. The temperature was normal. No abnormality of the internal organs was found. Widal tests were negative for typhus, paratyphus *A*, and paratyphus *B*. The Wassermann and Sachs-Georgi tests were also negative.

At operation on April 5, 1923, through a curved incision, the muscles were found to be infiltrated. A fistula was revealed on the lower border of the seventh rib, and resection of the sixth and seventh ribs disclosed a peripleuritic cavity filled with caseous and disintegrated material. On the inner surface of the fifth rib there was slight necrosis of the tissues, and above the inner side were found small lymphatic glands showing caseous degeneration. The cavity was thoroughly cleaned, its walls were swabbed with iodine, and the cavity was closed. Healing was by primary union. Observations in 1925 showed a thick scar adherent in one portion to the deeper structures. Recovery had taken place rapidly.

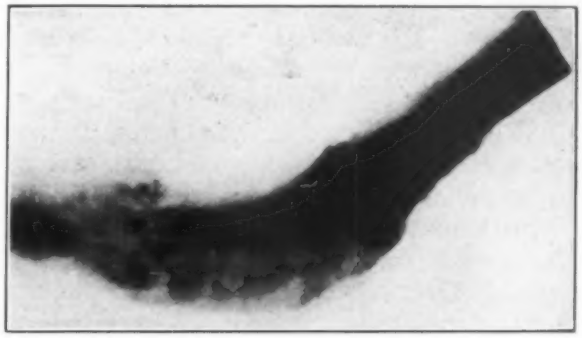

FIG. 3
Roentgenogram showing tuberculous perichondritis.

This case endorses the opinion that in most cases the rib and the cartilage are affected secondarily, and that specific changes in lymphatic vessels and glands are responsible for the invasion of the surrounding tissues. In confirmation of this is the interesting fact that the radiocarpal joints of children under four never become tuberculous, for the reason that up to this age the joint remains entirely cartilaginous. The anatomical fact that the tuberculous abscesses of the thoracic wall are frequently located in the linea parasternalis or in the linea scapularis posterior also substantiates this opinion. The intercostal vessels, opening into the thoracic duct, are interrupted by the

FIG. 4
Roentgenogram showing tuberculous periostitis of the rib.

intercostal glands which lie at the level of the rib ends. The anterior intercostal vessels are interrupted by the anterior mediastinal glands at the point of union between the costal cartilages and the sternum. These glands interrupt also the passage of the internal mammary lymphatics.

In a case of resection of the third cartilage, in connection with an abscess on the side of the chest, there were no great changes found in the cartilage. The abscess led to the under side of the sternum, which was partly resected; on the posterior surface, very slight changes were observed. The tuberculous character of the lesion was proved and recovery took place rapidly.

The anatomy of the lymphatic system and the pathological changes which are located in definite places endorse the opinion that primarily the glands adjacent to the pleura are the first to become infected, following which perichondritis or tuberculous periostitis occurs, from which develop the cartilaginous or bony lesions in proximity to the abscess. It is probable that the extension of the tuberculous focus occurs through the lymphatic rather than through the vascular system.

It is characteristic of tuberculous perichondritis that the development is insidious and without definite cause. There may be observed a slight thickening of the cartilage of the breast, or an abscess may appear in the bone cartilage. A limited amount of thickening of the cartilage, if of a tuberculous character, indicates that the process is localized and adjacent to the pleura, but has not yet extended to the surface of the cartilage. If the abscess has already developed, tenderness over the area of the cartilage increases. The abscess may gravitate downward behind the rib or cartilage and appear at a point distal to the original focus, which makes more difficult the localization of the point of origin.

Occasionally a cold abscess arises from the osseous-cartilage border and gravitates under the ribs, simulating perichondritis. Rarely does an abscess gravitate inward into the mediastinum or into the pleural cavity, and such an abscess was not observed in the author's series of cases.

With lesions of the cartilage, however, abscesses nearly always localize themselves in close relation to the infected rib and do not gravitate. They do not in any way differ from cold abscesses of bone tuberculosis in general. Abscesses may, however, be found in different parts of the thorax. In two cases spondylitis and tuberculous perichondritis were observed simultaneously. There is apparently no constant relation between the infection of the cartilage and the infection of the lungs or of the pleura. (A history of pleurisy was established in three cases.)

During a typhoid epidemic, in a few patients there developed a swelling in the region of the cartilage of the ribs, which, in some of the cases, proved at operation to be tuberculous perichondritis. Diagnostic difficulties may be appreciated from the statement that in three of these cases the diagnosis had been typhoid chondritis.

The clinical picture, the bacterioserological data, and experiments on animals have yielded definite information for differential diagnosis.

Tuberculous abscesses on the anterior chest wall attain to larger size than those of typhus or of paratyphus origin, and develop slowly without noticeable changes in the skin.

Typhoid chondritis is more frequently seen in the cartilages of the sixth and seventh ribs, probably due to the early vascularization and ossification of these cartilages. Tuberculous chondritis may occur in any cartilage and often is found above the sixth rib. In tuberculous perichondritis the general condition is more serious and is accompanied by a loss of weight and subfebrile body temperature. In typhoid chondritis the course of the disease is prolonged and the roentgenogram shows early ossification around the inflammatory focus. In tuberculous perichondritis slight evidence of ossification appears only late in the disease. If periostitis or perichondritis occurs with the tuberculous process in other locations, the prognosis is unfavorable.

In regard to the treatment of these conditions, observers differ. Some recommend radical operation with resection of the rib and closure [8]; others consider it insufficient to puncture or to inject the area and state that it is necessary to remove the focus as far as possible within healthy limits without opening into it, and that the cartilage must be removed [6,7]. Still others recommend puncture or injection of different solutions; x-ray therapy for tuberculosis has always received considerable attention.

From 1921 to 1933, ten cases of tuberculosis of the ribs and cartilages were operated upon.

In the case of tuberculous lesions of the cartilage of the rib, radical resection of the cartilage is employed [3]. The bony process is resected as early as possible, re-

FIG. 5-A
Roentgenogram showing tuberculosis of the rib.

FIG. 5-B
Specimen showing tuberculosis of the rib. Same case as in Fig. 5-A.

gardless of the localization of the focus which does not require opening. The anterior perichondrium, with the cartilage, is removed; the posterior perichondrium, in the form of a band, remains on the pleura. At the intercostal articulations the diseased cartilage is removed without injuring the area of the sound cartilage. By this means, there is left at the fifth cartilage, above the articulation of the sixth and seventh cartilages, a stump deeply hidden under the perichondrium. The wound is closed without tension on the skin.

TABLE I

TREATMENT AND END RESULTS OF FOURTEEN CASES OF TUBERCULOUS PERICHONDRITIS

Procedure	Healed	Fistula	Death	Total
Radical resection of the cartilages	5	2	1	8
Opening of abscesses	1	1	0	2
Conservative treatment	2	2	0	4
Total	8	5	1	14

Radical operation is to be performed only in the early stages of the disease when the thickening of the ribs or of the cartilage is slight. After this period, and if an abscess has formed, the conservative treatment is advisable. If a fistula is present, and if the patient is in good condition, a radical operation may be indicated; in this case, however, it is necessary to determine exactly the primary source of infection. Before operation, it is advisable for therapeutic reasons to inject from five to eight cubic centimeters of Calot's emulsion.

Of the ten patients in the author's series, eight were operated upon by the radical method. Primary union was obtained in three of the early cases. In two cases the fistula remained and did not heal during seven months of observation. In one case of miliary tuberculosis, operated upon in the abscess stage, death followed in one and one-half months after operation. In this case operation was not advisable. In only two cases were the abscesses opened and in each of these the origin of the abscess was not found and resection of the ribs was not performed. In one case there was recovery with heliotherapy; in another, a fistula remained. If a fistula remains after operation, it is wise to carry out systematic treatment of injection with Calot's emulsion.

We may thus state that operative treatment gives the most satisfactory results in the early stages of the disease. The operation must be radical and the wound closed. Conservative treatment in perichondritis and periostitis is more adapted to the stage of abscesses and fistulae. General treatment by heliotherapy, diet, etc., is always indicated. Calot's emulsion has proved effective in treating abscesses and fistulae.

From a study of the cases the following observations have been made:

1. The rib cartilages in the majority of cases become secondarily

infected and are the medium through which the disease extends from the adjacent peripleural lymphatic vessels or glands.

2. As opposed to typhoid chondromyelitis (chondritis) in which the cartilage and marrow become primarily affected and destruction proceeds from the center to the periphery, in tuberculous perichondritis the destruction begins almost always in the periphery and extends to the deep-lying parts of the cartilage.

3. Operative treatment of tuberculous ribs and cartilages gives the most favorable results up to the time of the formation of the abscess. Curettage and partial resection are irrational. Operation must consist of the radical removal of the entire cartilage. Thorough evacuation of the caseous material in the cavity is followed by closure. In lesions of the bony portion of the rib it is possible to limit the resection, thus avoiding injury to the cartilage.

4. In the abscess and fistula stage, conservative treatment is indicated. Consistently good results have been obtained from the systematic injection of Calot's emulsion.

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TUMORS OF THE PELVIC GIRDLE

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Tumors of the pelvic girdle present a diagnostic and therapeutic problem which has been all but ignored. Forty-one cases admitted to two hospitals during a five-year period suggest that they are by no means rare. These cases did not include instances where pelvic-bone involvement represented merely the terminal phase of a generalized metastasis, but were chosen because the tumors were an important part of the clinical picture. Of the forty-one cases included in this series, twenty-one or about 50 per cent. were primary tumors. The remainder were metastatic. This is a much higher percentage of primary neoplasms than is ordinarily suspected to occur in the pelvic girdle. The primary tumors were classified as follows:

	Cases
Osteochondroma	4
Osteogenic sarcoma	5
Fibrosarcoma	5
Ewing's myeloma	4
Lymphosarcoma	1
Undiagnosed	2
Total	21

Of the metastatic tumors, seventeen were carcinomata, one was a myosarcoma (primary in the uterus), and two were hypernephromata. All but four of the tumors were malignant. Five fibroblastic sarcomata and one lymphosarcoma were soft-tissue tumors invading the pelvic bones from adjacent soft tissues.

It may be said that in general the presenting clinical picture was that of a tumor of the pelvic bones, and, except for the rapidity of development or of fatality, the symptoms were not influenced by the pathology of the neoplasm. Tumor of the pelvic girdle can be suspected at any age, although it is more frequently found during the third, fourth, and fifth decades. The youngest specimen in our series was an osteogenic sarcoma of the ilium in a child of eleven. The oldest was a metastatic carcinoma of the ischium in a man of seventy-four. Sex plays no part in the differential diagnosis.

In thirty-seven of the forty-one cases (all but four) the presenting symptom was pain. In twenty-four cases the pain involved the extremity and was described either as radiating down from the buttock, or as preceding any local pain at the pelvic girdle. Although each case varied somewhat in the detail of onset and in its time relationship to pain at the

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hip or the buttock, the important generalization can be made that the presenting complaint was such as to suggest some form of the so called sciatic syndrome, lumbar radiculitis, or sacro-iliac syndrome. In thirteen cases the pain was referred to the lumbar spine, lumbosacral region, or sacrum, presenting the clinical picture of "low-back pain". In several of these cases, radiation down an extremity followed some time after the onset of back pain. In almost every instance, the reflexes and other gross neurological manifestations were recorded. These were of little help. In young cases they were negative except in advanced stages where peripheral nerve involvement occurred. In the older cases they represented the possible findings of root pressure or unrelated spondylitis or radiculitis. In two cases—one a female of thirty with an extensive osteochondroma of the ilium, the other a female of sixty-one with a fibrosarcoma attached to the pelvic bone—swelling or tumor was the presenting complaint. Pain was either absent or negligible.

In ten cases there was a history of injury. This varied from a fall on the buttock to a fractured hip. The story of strained back was given in five of the cases. These histories were important in that they directed the examiner's attention away from the possibility of neoplasm. Seven of the patients in the series had been treated for weeks or for months by physiotherapy or by manipulations. Among the carcinomata several were of particular interest. In eleven out of seventeen of these cases no symptoms of visceral carcinomata were previously complained of. Pain in the legs or lower back was the presenting complaint of patients subsequently discovered to be suffering from carcinoma. In eight of these, the site of the primary neoplasm was never discovered.

The duration of symptoms varied from eight weeks to two years, with few exceptions. The symptoms in two of the cases of osteochondroma had lasted for eight years, appearing recurrently; in one of the cases of metastatic carcinoma the duration was five days. Most patients described symptoms of from three to six months' duration. Out of this general clinical picture, however, one symptom was prominent. In nine of the cases, some time after the onset of pain (from several weeks to several months), the patients complained of "weakness" in the affected extremities. This weakness was a motor disability, even though definite motor paralysis could seldom be distinguished. It led often to an early exaggerated limp not associated with the severity of the pain.

In this brief report we wish to call attention to several specific observations:

1. Tumors of the pelvic girdle are not rare. Half of them are primary tumors if one excludes cases in which pelvic involvement is merely the terminal phase of a generalized metastasis.

2. They are most liable to present the clinical picture of an atypical sciatic or sacro-iliac syndrome, or that of "low-back pain".

3. Motor disability of a non-specific character in an extremity during the course of a sciatic or sacro-iliac syndrome calls for a roentgeno-

graphic study of the pelvis even though previous roentgenograms have been negative.

4. A consideration of pelvic-girdle tumor must enter into every routine examination of the patient with "low-back", "sacro-iliac", or "sciatic" symptoms.

The relationship between the location of the tumor and the area of radiating pain is an interesting side-light on the sciatic problem. Of twenty-five patients in whom the nature of the pain radiating into an extremity was in a broad sense of the sciatic type—that is, following the posterior aspect of the thigh, the calf muscles, the ankle, or any combination of these—the tumors were found in the following locations:

Region	*Cases*
Sacro-iliac	6
Alae of ilium (not at sacro-iliac joint)	10
Acetabulum	3
Lower ilium and trochanter	1
Ischium	1
Pelvic bones (multiple foci)	2
Sacrum (not at sacro-iliac joint)	2

This distribution tends to confirm the observation that the sciatic or sacro-iliac syndrome may be due to any factor which disturbs the muscular mechanics about the gluteal or iliac region, and is not specifically related to affections of the sacro-iliac joint, the sciatic nerve, or any definite muscle.

One further fact must be noted. A negative roentgenographic report relates only to the absence of abnormal shadows at a given time. In several of our cases, roentgenograms had been reported negative up to within six weeks of admission. In a protracted case of this kind, a single negative roentgenographic finding must not preclude reexamination.

FASCIAL TRANSPLANTS IN PARALYTIC AND OTHER CONDITIONS *

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The prevention and correction of deformities of the spine and the trunk, which develop so rapidly and extensively in the course of infantile paralysis, have always presented great difficulties. Muscle training, supports, and stabilizing operations on the spine have all been helpful, but have left much to be desired when the final results of treatment were evaluated. Lowman in 1932 and Mayer in 1936 reported several cases in which the action, or at least the stabilizing effect, of abdominal muscles was recaptured to some extent by the use of fascial strips, sutured to healthy muscles and passing over to be attached at the insertion of the weak or paralyzed muscles, or passing from bony point to bony point. The results reported were sufficiently satisfactory to challenge attention and the method seemed to be a distinct step forward in the management of paralytic deformities of the spine and the trunk.

Impressed with the possibilities which these observations suggested, we checked over our old cases as the opportunity presented and began making more careful examinations of all of our new cases with respect to weakness or paralysis of the muscles of the abdomen, the chest, and the spine, and to the effect of such weakness upon stability of the pelvis and the trunk, and upon the effectiveness of the muscles of the extremities. Our observations led us to about the same conclusions that Lowman had arrived at with regard to the important part played by weakness or paralysis of these muscles in the production of distortion and instability of the trunk and the pelvis and of interference with the functioning of the muscles of the extremities because of this loss of stability. Accordingly, we began to carry out the procedure suggested by Lowman for recapturing the power of weak or paralyzed muscles of the abdomen, the spine, and the chest. While seldom spectacular, the results seemed decidedly worth while, and we have continued to follow this procedure as the occasion arose. The object of this report is not, however, to present a mass of material with definite conclusions based upon a number of results, but, rather, to offer our experience in a few cases as a suggestion for future exploration in what seems to be a very promising field.

In our experience the greatest difficulty encountered in using fascial transplants has been in determining what muscles or groups of muscles are chiefly at fault. Lowman and Mayer have indicated useful tests which have been helpful, but there is yet much charting to be done before even an approximately sure course can be steered. The determination of weakness in the upper and the lower recti and the abdominal obliques is

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FIG. 1

Fascial transplant to replace the paralyzed quadratus lumborum.

not difficult, since Beevor's sign, or shifting of the umbilicus upward, downward, or to one side or the other when the head is raised against light resistance, and loss of muscle tone are fairly accurate guides. The determination of weakness in other muscles—the quadratus lumborum, the latissimus dorsi, the serratus anterior, the rhomboidei, and, at times, the trapezius—is not so readily made and requires much study, and then one is not always sure. In our experience, the reason for this lies in the difficulty of isolating the action of these muscles because of their intricate and complex relationship in function with each other and with other muscle groups. However, it has seemed from our examinations that weakness in all of the muscles mentioned has been a factor in the production of deformity or of interference with function in some cases, and, when feasible, an effort has been made to replace their lost action or to recapture as far as possible their stabilizing influence by attaching fascial transplants from unparalyzed muscles to a fixed bony point.

It seems unnecessary to discuss plastic repair of the abdominal muscles, since this ground has already been most carefully and exhaustively discussed by Lowman and Mayer, and this phase will, therefore, be but briefly touched upon. There are, however, certain fascial transplants about the shoulder which have seemed helpful from our experience with them, and it is these which we wish to discuss in more detail.

Our experience with abdominal plastic repair is based on forty-four cases with the following distribution: superior rectus, one case; inferior rectus, eleven cases; upper oblique, seven; lower oblique, twenty-six; quadratus lumborum, eight (Fig. 1); and various combinations of these. In these cases the benefits which have been derived may be catalogued as follows: (1) improvement in general health; (2) greater endurance, as determined by ability to walk greater distances and to get about more extensively with less fatigue; (3) ability to lift the foot from the ground and to take steps when this has been impossible before operation; (4) ability to go up steps; and (5) in two cases ability to walk without brace or support when formerly both were necessary. Unfortunately, we have had no opportunity to test the value of the procedure in preventing the occurrence of spinal deformities, as we have seen no early cases of infantile paralysis since we have been carrying out these transplantation operations.

Fascial transplants about the shoulder, for the purpose of stabilizing the scapula and thus preventing or minimizing deformity of the chest and the cervical region and improving the function of the muscles of the upper extremity, have, we feel, proved useful in two types of cases:

(1) Paralytic scoliosis with drop shoulder and marked cervical curvature;

(2) Paralysis of the scapular muscles with asymmetry of the shoulder, deficient stability of the shoulder girdle, and developing high thoracic curve.

PARALYTIC SCOLIOSIS WITH CERVICAL CURVATURE

The cases included in this group are those in which, because of weakness or paralysis of the spinal and the scapular elevator muscles, there occurs a descent of the shoulder on one side, and a high cervicothoracic curvature develops. (See Figure 2.) This type of spinal deformity has in our experience been very difficult to prevent and most resistant toward all efforts directed against its tendency to become progressively worse. Confronted with a problem, no solution of which has ever been entirely acceptable, it was thought that any procedure which would elevate the dropped shoulder and hold it in that position should help to some extent in relieving the distortion of the upper trunk and neck and would be worthy of trial even if other deformities of a serious degree were present below this level. Accordingly, it was decided to use fascial strips for this purpose. The objective was twofold: (1) to elevate the dropped shoulder, and (2) to provide a fixator action against the pull of the unparalyzed muscles on the convex side of the cervical curve, which is concave toward the side of the depressed shoulder. To accomplish these two objectives, two fascial strips were used,—one was passed from the spine of the scapula to the cervical muscles on the concave side of the cervical curve, and the second was passed from the spine of the scapula to the spinous process of the first thoracic vertebra. (See Figure 3.)

FIG. 2

Dropping of the right shoulder and high cervical curve with increasing deformity. This is the type of case considered suitable for operation.

The procedure was carried out as follows: Through an appropriate incision, the spine of the scapula was exposed well outward toward its acromial end, and a slot was made through the spine. An incision exposing the cervical fascia was then made, extending from the spine of the scapula to the apex of the cervical curve on its concave side. Next, a strip of fascia lata, which by suturing the edges with fine catgut had been converted into a tube with the gliding surface out, was laced into the cervical muscles at the apex of the curve on the concave side. The depressed shoulder was then elevated as much as possible, and the fascial tube was passed through the slot in the spine of the scapula and fastened with silk. An incision was then made over the spinous process of the first thoracic vertebra, and a hole was drilled through the spine at its base. A fascial strip, looped through a second slot made at the vertebral end of the spine of the scapula, was passed through a subcutaneous tunnel to the spine of the first thoracic vertebra, drawn through the hole, and sutured under tension. The incisions were closed in layers and a plaster cast was applied with the arm in abduction of from 40 to 50 degrees, or the shoulder was attached to the head of the bed. At the end of three weeks exercises were begun, and at the end of from five to six weeks all support was removed.

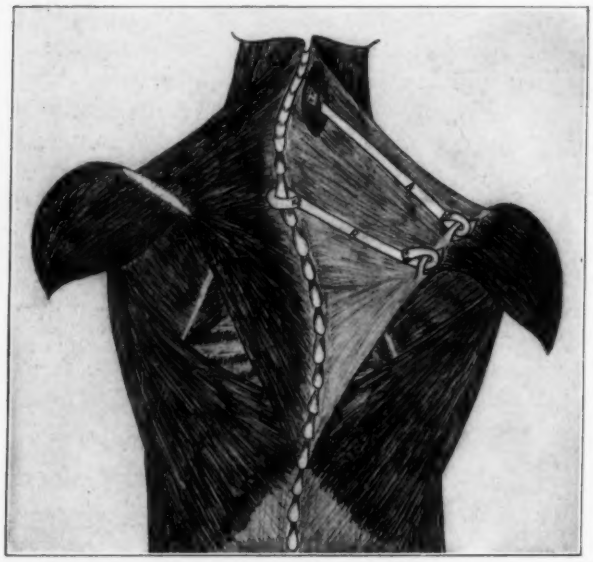

FIG. 3

A: Fascial strip running from the spine of the scapula to the cervical muscles. *B:* Fascial strip running from the spine of the scapula to the spinous process of the first thoracic vertebra.

It should be mentioned that in these cases the second transplant, running from the vertebral end of the spine of the scapula to a hole drilled in the spinous process of the first thoracic vertebra, was used to give additional support and anchorage, so that the entire strain of supporting the shoulder would not come upon the cervical muscles.

The procedure was carried out in six cases and has proved satisfactory beyond our expectations. In all cases the shoulders have remained elevated to a satisfactory degree and no support has been necessary. In addition, there has been no increase in cervical deformity, and in every case there has been some improvement,—all of these patients report a

definite decrease in neck pain and fatigue and a more comfortable feeling generally since the operation. The most extreme case in which the operation was performed was that of a girl, sixteen years of age, who, although she had previously had a successful stabilization of the lower spine, continued to have dropping of the right shoulder, increasing cervical deformity, and increasing limitation of neck motion with pain which eventually became so disturbing that it was necessary to put the patient in the hospital and to apply head traction. Following operation, the shoulder remained elevated quite satisfactorily without support, the neck pain disappeared, and there was a very satisfactory increase in the range of neck movement. Four of these cases have been observed for three years after operation and two for two years.

FIG. 4

Same patient as in Fig. 2, four weeks after operation. The patient states that there is distinct improvement in the movement of the neck and feeling of comfort. Sufficient time has not elapsed for final result.

PARALYSIS OF THE SCAPULAR MUSCLES

In this group the main difficulty to be overcome was lack of stability of the scapula, due to weakness or paralysis of muscles running from the spine and the trunk to the scapula. Weakness of these muscles resulted in hypermobility of the scapula which prevented effective use of the shoulder joint. There was also a tendency for a high thoracic and even a cervicothoracic curve to develop. It was felt that stabilization of the scapula, by providing a more normal resistance to the action of unparalyzed scapular and thoracic muscles, would have a restraining effect upon the development of spinal deformity and would to some extent improve shoulder-joint function.

In one case there was considerable hypermobility of the scapula, which moved inward toward the vertebral column and rotated downward and inward when the shoulder was abducted, and a high thoracic curve was beginning to develop. There was some atrophy of the rhomboidei and the trapezius. Since it is the serratus anterior which

FIG. 5

A: Fascial transplant from the lower vertebral border of the scapula to the spinal muscles. *B:* Fascial transplant from the lower vertebral border to the latissimus dorsi muscles.

draws the scapula laterally and keeps it applied to the ribs, this muscle seemed to be the muscle most seriously involved. To replace the action of the paralyzed serratus anterior, a fascial transplant was fastened in a slot made at the lower axillary border of the scapula and passed forward through a subcutaneous channel. The distal end was split and one section was laced into the lower fibers of the pectoralis major and the other into the anterior fibers of the latissimus dorsi; the fixation was made with the scapula drawn forcibly toward the axilla and with the fascial strip under strong tension. The purpose was to prevent the movement of the scapula toward the vertebral column and thus to secure stability. Theoretically it was hoped that the pull on the transplant would provoke a response in the pectoralis major and the latissimus dorsi and give some additional active pull on the scapula. The result of this procedure was a partial anchoring of the scapula which did not move toward the vertebral column so strongly, but remained more or less fixed. However, rotation of the upper border downward and inward was not prevented, and some dropping downward of the shoulder persisted. To overcome this rotation, a second transplant, running from the spine of the scapula to the cervical muscles, was used. This has given added stability and, we believe, has lessened the tendency to dropping of the shoulder. The result in this case is too recent to enable any conclusions to be drawn as to the effect of the procedure upon the course of the cervicothoracic curve. The improvement in shoulder function, however, is definite, and we believe that, to this extent at least, the procedure has been worth while.

In a second case the scapula moved toward the axilla and tilted its upper vertebral border inward and downward with abduction of the shoulder. Such a displacement seemed to be attributable to an overaction or unresisted action of the serratus anterior and weakness of the rhomboidei and the levator scapulae. There was weakness of the shoulder move-

FIG. 6-A

FIG. 6-B

Before operation, showing bulging of the right chest wall, due to lack of resistance to the serratus anterior, caused by paralysis or weakness of the rhomboidei and the levator scapulae. A left high thoracic curve was also present. This had been progressive during two years of observation.

ments in this case and a gradually developing thoracic curve with a definite bulging outward of the rib cage on the involved side (Figs. 6-A and 6-B). Our observation convinced us that the action of the serratus anterior was unresisted, due to the loss of the fixator action of the muscles running from the spine to the scapula, and that, as a result, when shoulder movements were made, the scapula moved toward the axilla instead of re-

FIG. 7-A

FIG. 7-B

Same patient (Figs. 6-A and 6-B) three years after fascial transplant to the scapula, showing no increase, and perhaps some improvement, in the bulging of the chest wall to the right. During this time no support or treatment had been given.

maining more or less fixed. Loss of the resistance of the serratus anterior against the rib cage permitted bulging of the ribs on that side and produced a high thoracic curvature toward that side. Stabilization of the scapula was secured in this case (1) by passing a fascial transplant from a slot in the vertebral border of the scapula inward and slightly downward and lacing the distal end into the spinal muscles and (2) by passing a second strip downward and slightly outward into the latissimus dorsi into which it was implanted in the same manner. (See Figure 5.) These transplants anchored the scapula fairly firmly against the chest wall and prevented any lateral movement. The result after three years (Figs. 7-A and 7-B) has been restoration of practically normal use of the shoulder and the arm and no increase in what, during two years of observation, was a progressive lateral deformity of the upper thoracic spine.

It should be stated that in all these shoulder cases weakness of the abdominal recti and obliques was eliminated as a possible source of lack of stability in the shoulder, since Lowman had pointed out that paralysis or weakness of these muscles interferes with stability of the rib cage and consequently with the action of the serratus anterior and other chest muscles.

The technique of the operations carried out was essentially that of Lowman in that one end of each fascial transplant was fastened to an active muscle and the other end was given a bony attachment. While attachment of the fascia from one bony point to another bony point, as advised by Mayer, may have some advantage, it seemed to us to lack the very important feature of the active muscle pull which is possible with a muscle-to-bone attachment. In one feature our technique has differed from that which Lowman used,—all our fascial transplants were made in the form of a tube with the gliding surface out, while Lowman's transplants were made as flat bands. It was our belief that by using the tube form of transplant the possibility of adhesions was minimized and a nearer approach to a true tendon was secured. This seems to have been true, since all of the transplants which have been examined have responded actively when the muscle to which they were attached has been contracted.

COMMENT

It is with some hesitancy that these cases are presented, since there remains much spade work to be done before a really systematic set of transplants can be determined from the point of view of effectiveness. This report must be taken, then, as a preliminary one with only suggestive importance and without definite conclusions. There is as well the thought that perhaps reporting these cases at this time may stimulate a deeper interest in Lowman's pioneer work, which, it would seem, has not been as widely studied and used as it deserves.

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RIB-SPLINTER GRAFT IN SPINAL FUSION FOR VERTEBRAL TUBERCULOSIS*

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During the past few years we have had occasion to induce osteosynthesis of the spine in thirty individuals with tuberculosis of the vertebrae, employing the operative technique described by Henry and Geist and including invasion of the vertebral articulations recommended by Hibbs. The majority of these patients presented complicating visceral tuberculosis (pulmonary, renal, peritoneal), while paravertebral abscesses with and without sinus formation were found in most cases. Practically all of this group, at the time of operation, had been confined to bed for many months because of the complexity of the lesions. In the entire series the operative mortality was zero. However, one very disquieting event did occur in practically every case,—namely, when we began to hammer on the tibia to remove bone chips for the graft, it was found that we could depend upon the development of a state of shock at that point. In some patients the shock was not severe, but in others it required hours of careful attention and the administration of saline, glucose, ephedrine, and morphine to sustain the vital processes.

Because of this one complicating factor, it was considered advisable to seek a new source of bone for the graft. In May 1936, we first employed the rib for this purpose, carrying out our preparation of the graft bed in the same manner as before, but placing the rib graft in the form of splinters. Three cases have been so treated, and, although the postoperative period of observation is relatively short (five, four, and three months), the author feels that a description of the procedure and a report of the results are warranted at this time.

OPERATIVE TECHNIQUE

The patient is placed in a prone position on the operating table and prepared as for any type of fusion operation. The skin sterilization is carried well around on one side to permit the removal of rib segments. We have always used two operating teams,—one to obtain the graft while the other prepares the spinal bed and then places the graft. Other authors recommend preparing the graft bed first and then obtaining the graft, thus allowing some time for hemostasis to take place in the spinal wound which is packed with hot compresses.

The Graft: An incision is made over the ninth or tenth rib from the edge of the erector spinae muscle group laterally for a distance of about

* Presented at the Monthly Staff Meeting, Glen Lake Sanatorium, September 16, 1936.

fifteen or twenty centimeters. Retraction of the wound edges will then allow exposure of the underlying ribs which can be removed subperiosteally by incision and stripping of the periosteum in the same manner as that carried out in the usual thoracoplasty. Segments from alternating ribs, measuring from ten to twelve centimeters in length, are obtained. Alternate ribs are sectioned to prevent the collapse of any appreciable volume of lung. These segments of rib are then cut transversely into three pieces and these in turn are split longitudinally into splinters which measure roughly four centimeters in length and two or three millimeters in diameter. These splinters are placed in warm physiological saline solution to which are added two or three bloody sponges. Into the same container are placed the irregular fragments of the spinous processes which are obtained by the other operating team. (See Figure 1.)

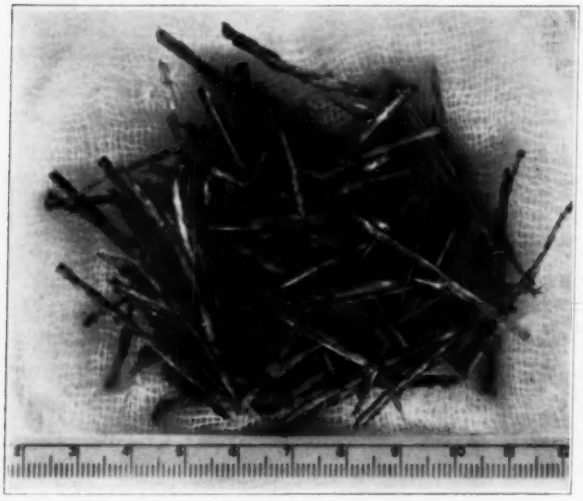

FIG. 1

Preparation of Graft Bed: An incision is made in the midline, from the tip of the third spinous process above to a similar distance below the involved (diseased) vertebrae. The dorsal fascia overlying the tips of the spinous processes and the interspinous ligaments, together with the periosteum over the process tips, are incised. Then, by careful dissection, this periosteum and part of the interspinous ligaments can be separated with the attached muscle bundles and retracted laterally. This procedure is carried on until the spinous processes and the laminae are denuded and the articulations are exposed. Sections of bone from the base of the spinous process and the laminae of each vertebra are then raised up with a small gouge or chisel and the spinous processes are sectioned at their bases. Destruction of the intervertebral joints is brought about by removing some of the cartilage and joint edges with a small chisel. (See Figure 2.)

To control bleeding, hot wet sponges are packed into one side of the wound while the other side is being worked on. When the bed has been thus prepared, the bone splinters obtained by the other team are packed into the wound. Each splinter is in intimate contact with the laminae and with each other, and they are roughly all in line.

Release of traction now allows the muscle bundles (erector spinae) to approach one another. A row of chromic gut sutures, deep in the muscle,

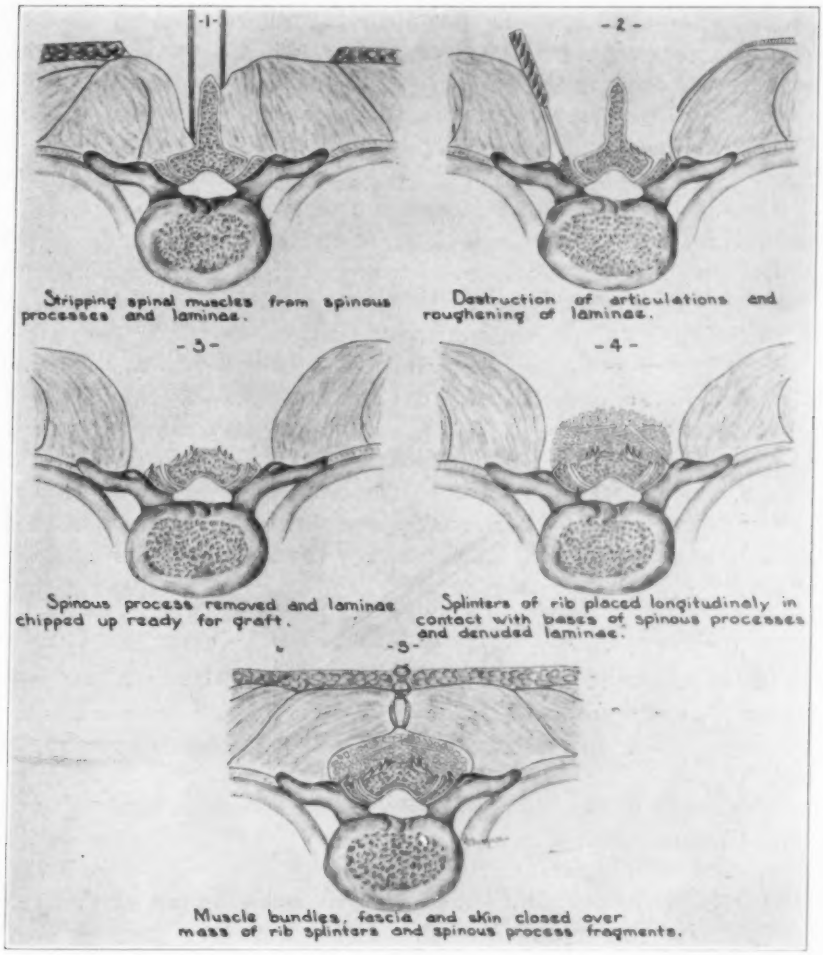
-1-
Stripping spinal muscles from spinous processes and laminae.
-2-
Destruction of articulations and roughening of laminae.
-3-
Spinous process removed and laminae chipped up ready for graft.
-4-
Splinters of rib placed longitudinaly in contact with bases of spinous processes and denuded laminae.
-5-
Muscle bundles, fascia and skin closed over mass of rib splinters and spinous process fragments.

FIG. 2

Rib-splinter bone-graft technique for spinal fusion.

pull them together without tension. The dorsal fascia and parts of the interspinous ligaments attached thereto are then approximated by a second row of similar sutures. A lock stitch of dermal closes the skin and a dry dressing is applied.

For the first week to ten days, the patient is allowed to assume any horizontal position in which he is comfortable. The stitches are then removed and the patient is provided with a posterior plaster shell or instructed to lie continuously on a firm mattress. This choice of postoperative care depends upon whether or not the patient can be trained to remain on his back and to roll like a log when turning over. If he cannot, a plaster shell is provided.

Ninety days after operation, if the roentgenographic appearance of the diseased area permits, an Osgood brace is provided and the patient is

gradually allowed to get up. Postoperative observations on the three patients so far treated by this procedure show that at thirty-day intervals new bone formation in the graft is steadily on the increase. Compared with observations in representative cases in which cortical grafts are used, we find a much more rapid proliferation of bone where the rib splinters are used.

Since most patients with vertebral tuberculosis must be treated by prolonged recumbency, because of the complicating visceral lesions, immediate strength of graft is not of importance. Therefore, solid rib or tibial grafts, anchored to the laminae and the spinous processes, are not, in the author's opinion, of as much value as a graft which in itself will resist little if any strain early, but which later develops into a thick plate of solid bone, extending well out on the laminae laterally and from the spinous process of the second or third healthy vertebra above and below the diseased area. Solid cortical grafts, then, present immediate strength, but a low-grade proliferative power, while rib splinters, composed of fine periosteal shreds, cortex, and endosteum, possess a high degree of osteogenetic ability, although they have little to offer early as a support.

SUMMARY

In the method of spinal fusion described, in which splintered rib is used for the graft, the articular facets are destroyed, because it has been felt, as Haas shows experimentally, that this procedure produces firmer fixation.

This method presents the following distinct advantages over other types of fusion operations:

1. The operative trauma is slight.
2. An accessible graft source, which supplies cortex, medulla, and endosteum for osteogenesis, is used.
3. Osteogenesis is very rapid.
4. The resulting graft is broad and thick and is attached to the whole surface of the laminae.

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THE BÖHLER CLAVICULAR SPLINT IN THE TREATMENT OF CLAVICULAR INJURIES

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*From the Hospital for Joint Diseases**

The use of the Böhler clavicular splint in the treatment of separation of the acromioclavicular joint has already been demonstrated[3, 5]. Since the publication of these cases the splint has been modified by Dr. J. E. Milgram to make it lighter and less cumbersome, and it has been used in the treatment of a variety of fractures of the clavicle with excellent results. The author believes that the apparatus is a worthy addition to the appliances used in the treatment of fractures of the clavicle. It provides for an important principle that is lacking in all of the methods used today.

The most common site of fracture is at the junction of the middle and outer thirds of the bone. The inner fragment is drawn upward by the pull of the sternocleidomastoid muscle, while the outer fragment tends to be drawn downward, forward, and toward the sternum by the pull of the pectoralis major and deltoid muscles. Most of the methods employed attempt to elevate and to retract the shoulder and with it the outer fragment, in the hope that it will bring the latter into alignment with the inner fragment, but no serious attempt is made to depress the inner fragment and to overcome the upward pull of the sternocleidomastoid muscle. The end result in most of these cases is overriding of the fragments and deformity at the fracture site.

An error commonly made is the application of some form of the numerous bandages or splints, with the expectation that the bandage or splint will effect reduction. The Sayre and Velpeau dressings do not reduce a fracture; they merely immobilize the shoulder and have the disadvantage of excoriating the skin. The T splint is advocated by the Fracture Committee of the American College of Surgeons[1], but Speed[2] comments on the fact that it does not elevate the shoulder and its usual result is some overriding of the fragments. The deformity that results from this method is due to the failure to provide downward traction on the inner fragment.

In order to effect reduction, it is necessary to raise the outer fragment, to correct the shortening by applying traction away from the chest, and, most important, to depress the inner fragment. The surgeon can best accomplish this by standing behind the patient, by placing the clenched fist in the axilla, by raising the shoulder, and (with the other hand against the patient's elbow) by pressing the elbow toward the patient's body. By this means, the overriding can be corrected. The inner fragment is then pressed down, and, in many cases of complete transverse fracture, the

* Service of S. Kleinberg, M.D.

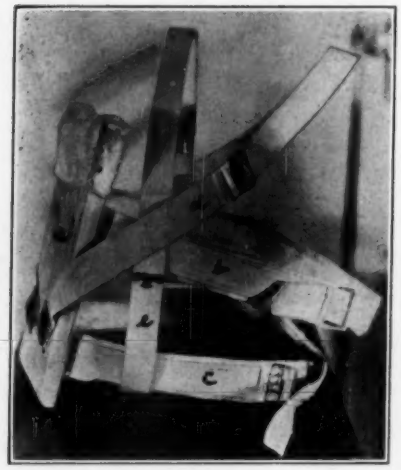

FIG. 1

Modified Böhler clavicular splint.

fragments can be hooked. To maintain this position and to prevent the inner fragment from slipping upward, the Böhler clavicular splint is used.

The author has described in detail the construction of the splint in previous communications. Briefy, the modified splint (Fig. 1) consists of a light board (*a*) of pine or balsa wood, five inches wide at the upper part, twelve inches long, and one inch thick. The board tapers down, the lower end being four inches wide. The upper part is rounded in concave fashion and is covered with thick felt to fit the axillary curve. Two malleable iron ribbons (*b* and *c*), twenty-six by one and one-half by one-eighth inches (the inner surface covered with felt, the outer with webbing), are attached to the main part of the board and are used to fasten the splint to the trunk. A third webbing (*d*) is fastened to the normal shoulder and is used to raise the splint and with it the in-

FIG. 2

The splint properly padded and applied.

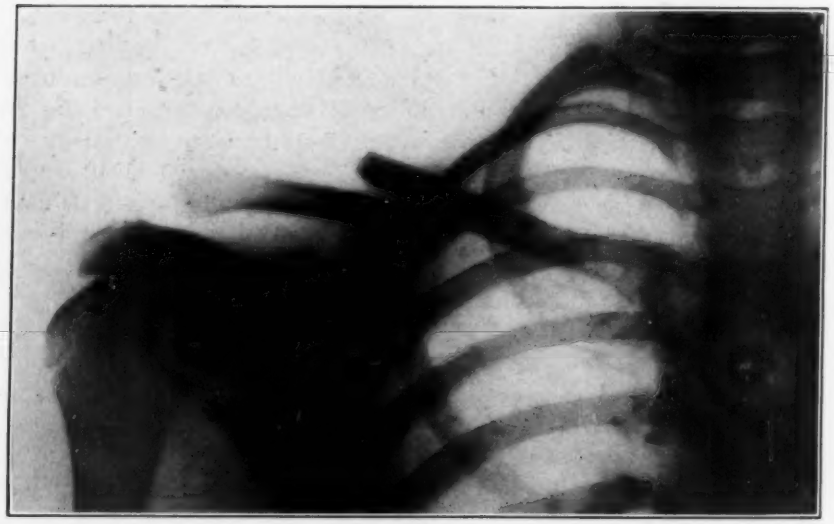

FIG. 3

Case 1. Typical fracture of the clavicle at the junction of the middle and outer thirds, with upward displacement and overriding of the inner fragment.

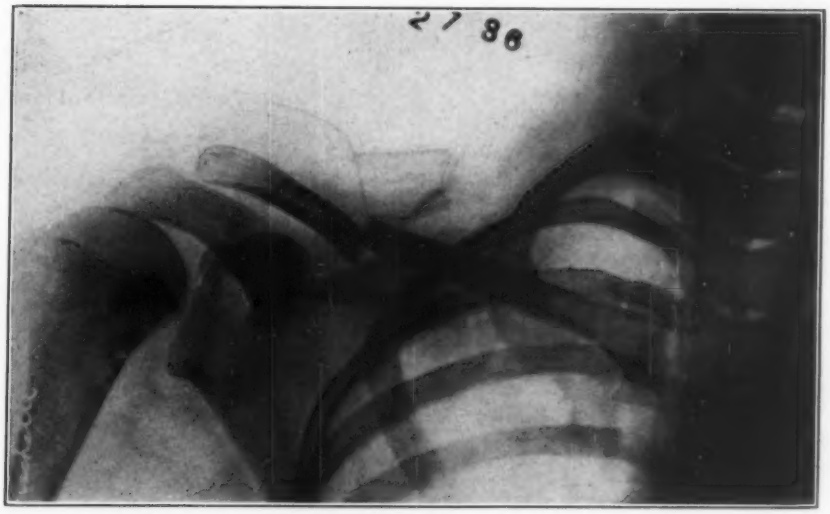

FIG. 4

Case 1. Fracture reduced and maintained by clavicular splint.

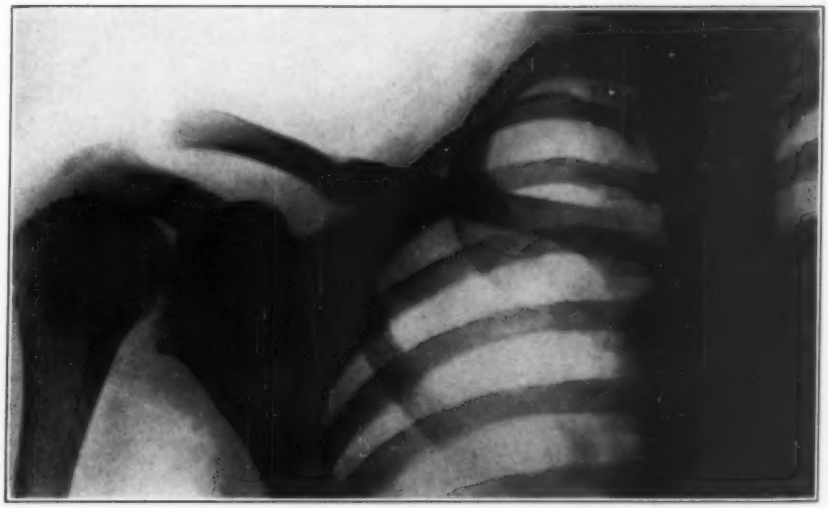

FIG. 5

Case 1. Four weeks after reduction. The splint has been removed and there is good alignment of the fragments.

jured shoulder. A fourth belt (*e*), with a buckle, is introduced under the lower iron ribbon and is used to press down the inner portion of the clavicle. (It is this belt that is the most important feature of the apparatus. Downward traction with adhesive strips is sometimes attempted, but retraction of the skin nullifies its effect, if any.) All parts are well padded and a small piece of felt is placed over the portion of the clavicle that is to be depressed. For children, a proportionately smaller size is used.

FIG. 6

Case 2. Oblique fracture of the clavicle in a female, aged sixty, with a loose fragment of bone at the site of fracture.

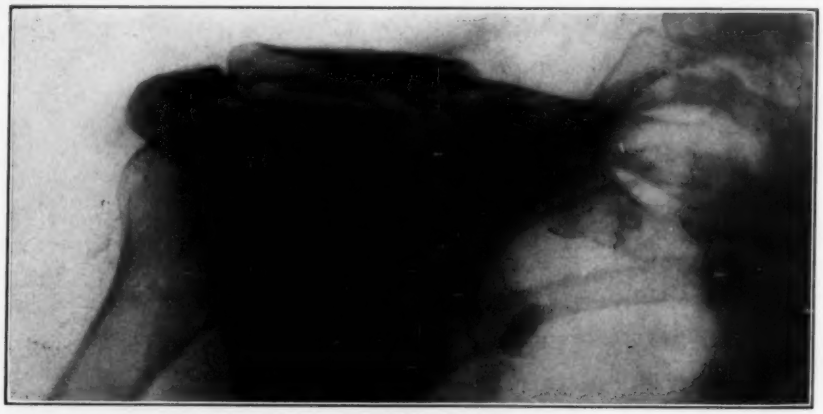

FIG. 7

Case 2. Six weeks after reduction. The splint has been removed and there is good alignment of the fragments.

The apparatus can be worn without discomfort (Fig. 2). Once fastened it needs little adjustment. The only care required is to tighten the buckle of the belt going over the injured shoulder in order to increase the pressure when needed. The extremity is free at all times; one need not fear stiffness of the shoulder or elbow, or subsequent atrophy of the muscles which often results when the extremity is completely immobilized against the chest wall. Once reduced, the fragments remain reduced, and, because of the fixed pressure of the webbing over the inner fragment, displacement cannot occur. The patient is ambulatory and does not require hospitalization.

This apparatus has been used successfully in the treatment of a number of different types of clavicular injuries. The following case reports will demonstrate the effectiveness of the splint.

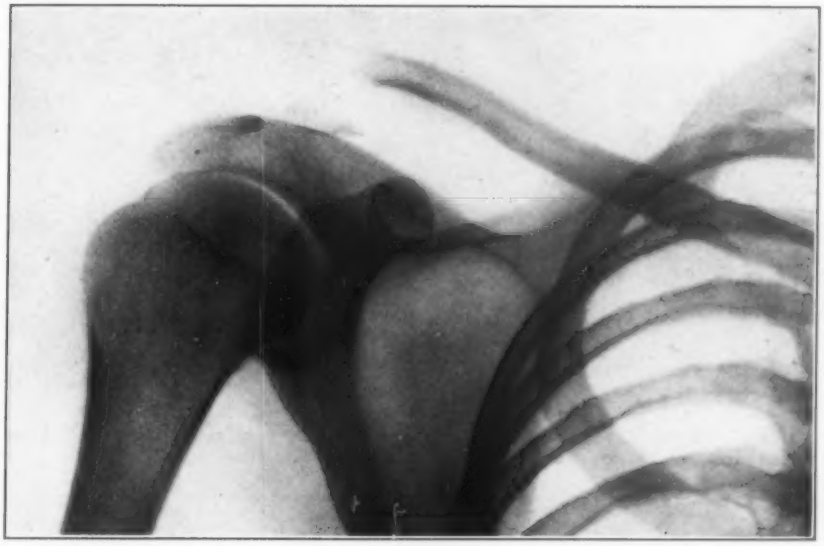

FIG. 8

Case 3. Fracture of the outer end of the clavicle, with tearing of the coraco-clavicular ligaments.

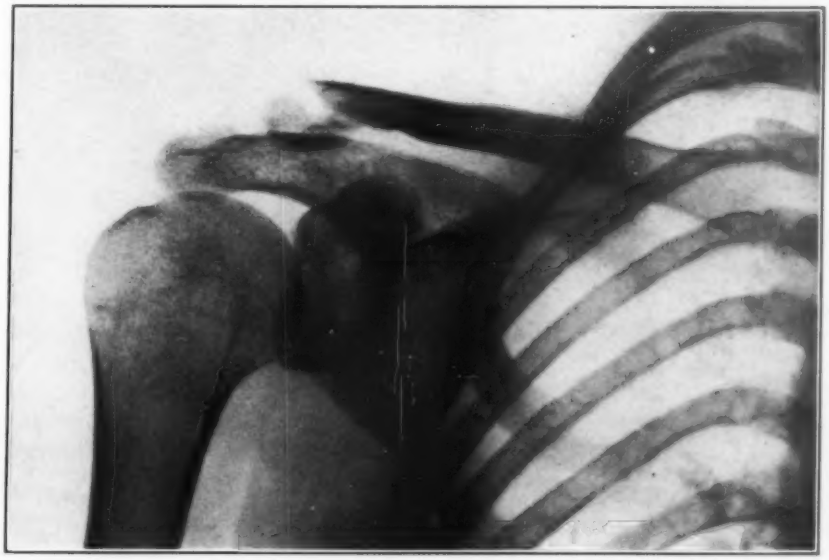

FIG. 9

Case 3. Six weeks after reduction, following removal of the splint.

FIG. 10

Case 4. Fracture of the inferior surface of the outer third of the clavicle and an oblique fracture through the acromial end.

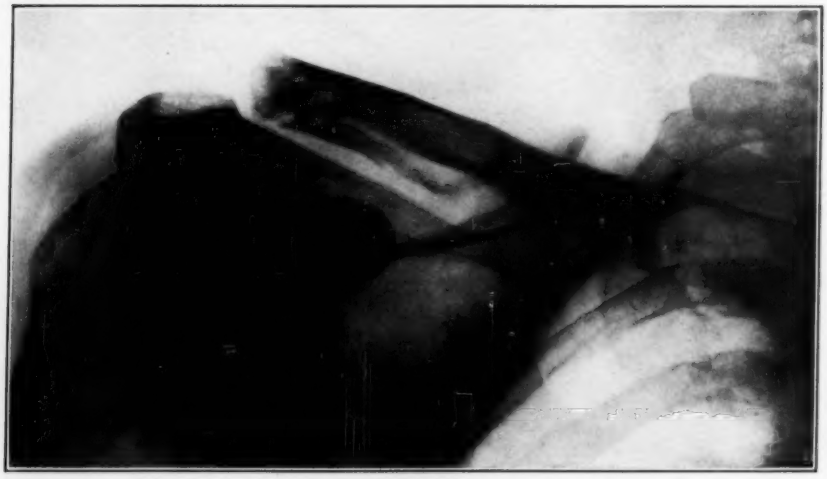

FIG. 11

Case 4. Alignment obtained after six weeks' treatment with the clavicular splint.

CASE REPORTS

CASE 1. A girl, aged ten, sustained a fracture of the right clavicle. A roentgenogram (Fig. 3) showed a complete transverse fracture at about the junction of the middle and outer thirds of the bone with upward displacement and overriding of the inner fragment. This is the typical form of fracture that is generally treated with a Sayre or Velpeau bandage or with a T splint, resulting in a deformity of the bone with a visible lump which is a very distressing feature.

Under local anaesthesia (five cubic centimeters of 2-per-cent. novocain), the fracture was reduced by the method described and the fragments were hooked (Fig. 4). The

splint was then applied and maintained for three weeks. The patient was observed every other day for the first week and the belt holding down the inner fragment was adjusted and tightened. A roentgenogram (Fig. 5), taken after removal of the splint, showed the alignment had been maintained, and that callus was present. In a few days, without after-treatment, the patient had a complete range of motion in the shoulder.

CASE 2. A female, aged sixty, was seen with a fracture of the outer portion of the middle third of the clavicle (Fig. 6); a loose fragment of bone was present at the site of fracture. In this type of fracture the fragments could not be hooked, but excellent alignment was obtained by depressing the inner fragment and by maintaining the position until callus had formed. Figure 7 shows the result six weeks after reduction.

CASE 3. A girl, aged sixteen, sustained a fracture of the outer end of the clavicle (Fig. 8). In this form of injury there must be some tearing of the coracoclavicular ligaments. Open operation was advised by several as being the only means of approximating the fragments. However, by maintaining constant downward pressure on the shaft of the bone with the Böhler clavicular splint, the fragments were held in apposition until united by firm callus. The apparatus was maintained for six weeks. Not only was union obtained at the area of fracture (Fig. 9), but the torn coracoclavicular ligaments were healed as in cases of acromioclavicular separation where healing was obtained in the torn acromioclavicular ligaments. This case was reported in detail in a previous communication[4].

CASE 4. A laborer, aged thirty-two, was struck by a truck, and sustained an injury to the right shoulder. There was considerable disability of the shoulder joint with swelling and deformity at the outer end of the clavicle. A roentgenogram (Fig. 10) showed a fracture of the inferior surface of the outer third of the clavicle, with separation of the bone from the shaft; and an oblique fracture through the acromial end of the clavicle, with angulation at the fracture site. There was also an incomplete dislocation of the acromioclavicular joint. This patient was seen one week after injury and had been treated with several forms of appliances and dressings without any improvement in the nature of the fracture. By means of the Böhler splint, pressure was exerted downward on the outer half of the bone and maintained for six weeks. A roentgenogram (Fig. 11), taken at the end of this period, showed excellent alignment and union. The patient returned to his work of delivering ice, several weeks later, without disability.

A word of caution against using this form of treatment in fractures of the inner half of the bone is necessary. In this type of fracture, especially in an individual with a short, thick neck, it is not possible to apply the pressure over the inner fragment. The webbing will slip over to the outer fragment and the pressure on that portion of the bone will cause a greater deformity.

SUMMARY

1. The methods commonly used in the treatment of fractures of the clavicle have received unfavorable comment by many authors.

2. The Böhler clavicular splint is advocated for use in the treatment of a variety of fractures of the outer third of the clavicle, where downward pressure on the inner fragment is required.

3. The patients are ambulatory and have complete use of the extremity at all times; thus stiffness of the shoulder and elbow joints and atrophy of the muscles are avoided.

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PROMOTION OF FRACTURE REPAIR *

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In the consideration of certain fractures which tend toward delay in uniting,—such as intracapsular fracture of the hip and fracture of the junction of the middle and lower thirds of the tibia—we have sought a substance to stimulate bone repair locally at the point of fracture.

Some proof of the value of local stimulation seems to be found in the high percentage of bony union following a local bone-grafting operation.

Johnson's success in influencing the processes of defense and repair in the peritoneal cavity with amniotic fluid provided the inspiration to attempt this work, a preliminary report of which follows. It seemed logical that the foetal substances contained in amniotic fluid might influence repair elsewhere in the body.

TECHNIQUE

In carrying out our experiments, thirty-six rabbits were used. With exceptions to be noted, these rabbits were females of the same breed and approximately of the same age and weight.

Under ether anaesthesia, the front legs were fractured at approximately the middle of the shafts of both bones by lateral pressure with the thumbs. Care was taken to break each bone completely. Difficulty was experienced in obtaining uniformity of fractures.

In the untreated control animals the bones were fractured, casts were applied, and no injections were done.

In the treated animals normal saline solution was injected into the sites of fracture of the left legs. The selected substance was injected immediately into the sites of fracture of the right legs, except in the animals marked "delayed injection". In this manner, saline was used as a common control against all other substances.

In every instance casts were applied immediately after fracture and two small holes were made laterally in the casts for further injections to the sites of fracture. The average amount of solution injected through hypodermic needles at the sites of fracture was four cubic centimeters. The average time between injections was four days.

After a period varying from sixteen to twenty-five days, the casts were removed and the legs were x-rayed.

* Presented before the Meeting of The Fracture Committee, American College of Surgeons, Boston, Massachusetts, January 15, 1937.

FIG. 1

X-ray 16 days after fracture. Untreated.

FIG. 2

X-ray 16 days after fracture. Treated 4 days after fracture with amniotic fluid T-597.

An attempt will be made to show in the accompanying illustrations the difference in density and size of callus and speed of repair in the treated legs, also the earlier medullary recanalization and homogeneous blending of bone at the sites of repair in those legs treated with amniotic fluid and its fractions.

In this work, as in all animal experimental work, individual variability of the animals made control by animal against animal less accurate than leg against leg in the same animal.

ROENTGENOGRAPHIC FINDINGS

Figure 1 shows the fracture sites in an untreated control animal. Because the bones are superimposed in one view, an impression of solidity is inferred, which is not borne out by the other view. With suitable allowance for this discrepancy, both legs show the same degree of repair.

Figure 2 shows the legs of an animal in which a fraction of amniotic fluid T-597 was injected into the sites of fracture of the right leg four days after the bones had been broken. At the same time salt solution was injected into the left leg at the sites of fracture. Injections were given to this animal every four days until three injections had been given. On the sixteenth day the casts were removed and the legs were x-rayed.

Attention is called to the degree of repair in the right or treated leg

FIG. 3

X-ray 16 days after fracture. Treated with amniotic fluid T-890.

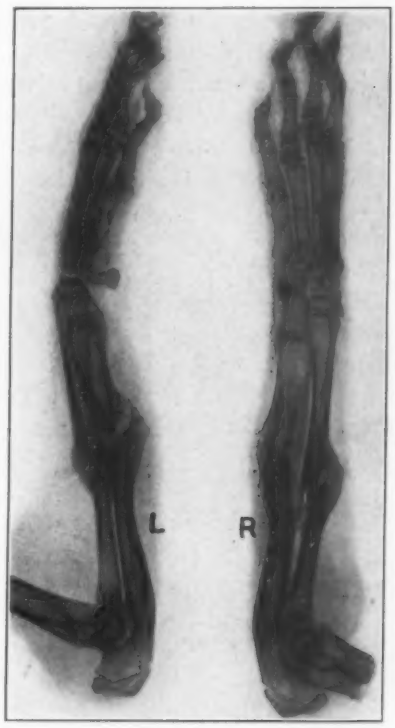

FIG. 4

X-ray 16 days after fracture. Treated with amniotic fluid T-890.

FIG. 5

X-ray 19 days after fracture. Treated with vitamin D.

FIG. 6

X-ray 25 days after fracture. Treated with amniotic fluid T-597.

as compared to the control leg which was injected with salt solution. It may be noted that calcification of the callus in the treated leg has progressed to a more advanced stage of repair than in the control leg. This may be measured by the density of the callus and by the size of the

FIG. 7

Photomicrograph 25 days after injection of normal saline.

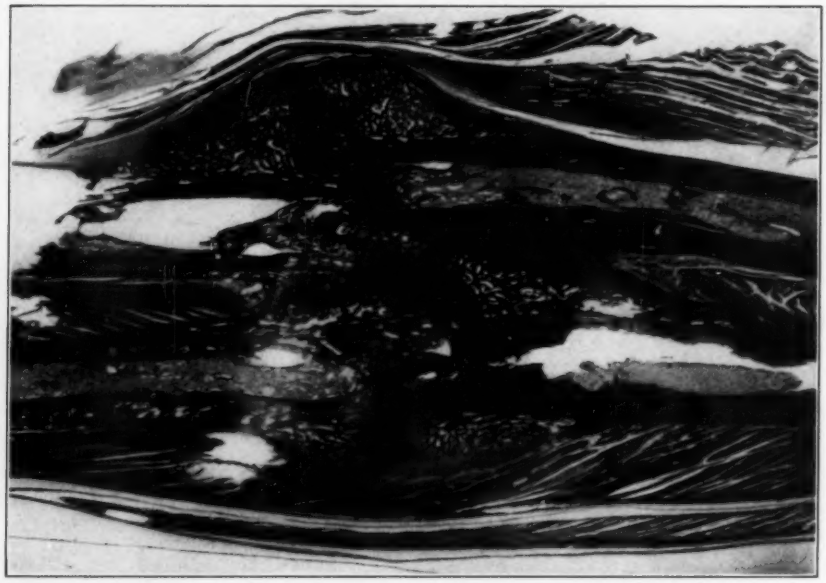

FIG. 8

Photomicrograph 25 days after injection with amniotic fluid T-597.

uncalcified gap in the control leg as against the almost complete obliteration of this gap in the treated leg.

Figure 3, the roentgenogram of an animal treated with a different preparation of amniotic fluid, T-890, shows about the same results as Figure 2. By comparison, a more advanced state of repair will be noted in the treated leg than in the leg injected with salt solution.

Figure 4, the roentgenogram of another animal treated with amniotic fluid T-890, offers further evidence of the value of this substance in promoting bone repair. There is completion of the callus outline with calcification in the right leg as compared with the incompletely calcified gap in the left leg. The callus in the right leg appears more dense than that in the left leg.

FIG. 9

X-ray 25 days after fracture. One injection of amniotic fluid T-597.

Figure 5 is the roentgenogram of an animal treated by concentrated vitamin-D injections and x-rayed on the nineteenth day. The bone repair is similar to that noted in untreated control animals.

Figure 6 shows the legs of a mature large rabbit, one year old, treated by a concentrated fraction of amniotic fluid T-597 and x-rayed on the twenty-fifth day. The degree of bone repair in treated and in control legs is quite similar to that noted in the young rabbit at sixteen days. This illustration is shown to demonstrate the relative speed of repair as compared to that in younger rabbits. The effect on this animal of stimulation by amniotic fluid is consistent, although repair was delayed. Because of the size of the uncalcified gap in the left leg, as shown roentgenographically, it was feared that some soft tissue might have been interposed between the fragments, thus delaying union. The animal was sacrificed and longitudinal sections from both fracture sites were made for histological study. Sections of this particular animal were rushed through to determine what type of tissue composed the rather large gap separating the bone ends. This region in the left or control leg (Fig. 7) is formed of cartilage, osteoid and osteoblastic tissue, and young callus. In the treated leg (Fig. 8) a narrow zone of cartilage and callus fills the gap.

Figure 9 is the roentgenogram of a young rabbit treated by one injection of amniotic fluid T-597 into the right leg at the time of fracture. Saline was injected into the left leg as a control. The injections were not repeated. The animal was x-rayed twenty-five days after fracture. The comparative results are striking,—in the right leg an advanced state of repair is apparent, including recanalization of the medullary cavity and complete bony union at the fracture sites.

In the untreated leg dense calcification may be seen at the sites of fracture, but the repair process obviously has not progressed to the degree noted in the treated leg.

SUMMARY AND CONCLUSIONS

Observations on a series of thirty-six animals are submitted to show the comparative stimulating effect of selected substances on the repair of fresh fractures when injected into the site of injury.

Leg-against-leg control in the same animal tends to eliminate discrepancies due to individual variability where animal is compared with animal.

Of the selected substances employed as stimulants to bone repair, amniotic-fluid concentrate gave the only definite results.

Injection may be done at the time of fracture or it may be delayed for from one to four days.

The results obtained in this experimental series suggest the clinical application of this treatment to fresh fractures in sites notorious for delayed union or non-union of bone.

SOME FACTORS WHICH INFLUENCE THE BALANCE OF THE FOOT IN WALKING

The Stance Phase of Gait *

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This subject is old. The method of investigation is different, if not new. The beginning of modern medicine includes references to the treatment of deformities of the feet. One finds also that the history of orthopaedic surgery requires generous space for a record of the multiplicity of efforts made to relieve discomfort in feet which were free from gross abnormal contours. Many text-books have described methods of treatment to relieve the symptoms. The young surgeon, with initial confidence, accepts them as informative. Time and experience with patients foster reservations regarding these text-book methods as each orthopaedic surgeon develops his personal method of treating painful feet.

Common physical and physiological factors are present in feet which are painful. The variable with relation to methods of treatment is expressed by those who prescribe for such patients. Each one of us may in personal confidence be satisfied with our individual solutions for the prevailing problems. However, such professional equilibrium finds continuity with empiricism, impressions resulting from trial and error. It becomes disturbed when all the various and bizarre methods of treatment are subjected to a basic premise resulting from recorded analyses of gait.

An interest in the phenomena of human locomotion has been sustained by one of us (R. P. S.) since 1919. Since September 1926, research on this subject has been in progress. Through this effort, instruments of precision essential to the analysis of gait have been developed. From the resulting records of "normal", lame, deformed, and hysterical subjects, certain concepts regarding the way we walk can be based upon reaction of the individual to prevailing methods of investigation. Thus removed from the conjectures and errors of visual analysis, the accumulation of 2,500 electrobasographic records reveals the indication for the presentation of facts relevant to a particular phase of the whole problem of human locomotion. In reality, the present discussion is limited to the stance phase of "normal" gait. This phase of gait is defined as the time interval between the placing of the heel and the lifting of the great toe from the floor. It is illustrated in Figure 1.

* Read at the Annual Meeting of the American Orthopaedic Association, Milwaukee, Wisconsin, May 20, 1936.

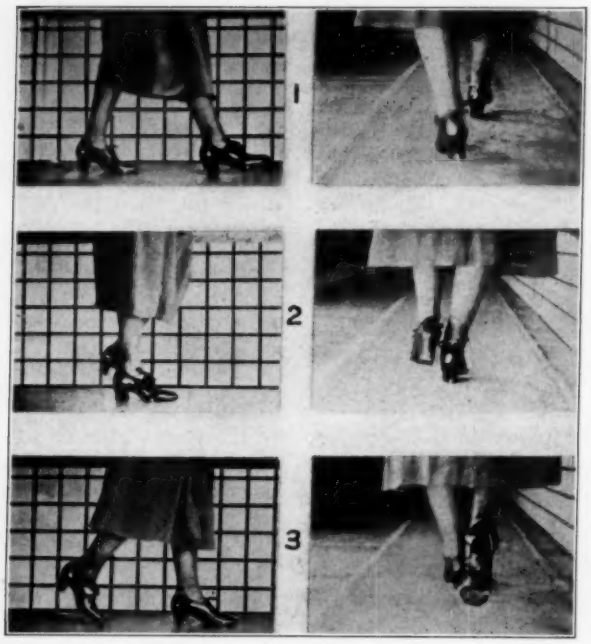

FIG. 1

Stance phase of right foot: *1* = heel contact; *2* = full weight-bearing; *3* = elevation of forefoot from the floor.

It is agreed that pronation, variable in degree, may exist in such a weight-bearing foot. Moreover, it is common to observe local and referred symptoms in association with such pronation. The converse is also true,—*i.e.*, these characteristic symptoms almost never prevail in the absence of pronation. It must be stated with emphasis, however, that some pronated feet are not painful. All such feet, with or without symptoms, function in a position which produces strain on all structures that are in abnormal relationships. They are, therefore, not in balance required for normal function, free from strain and from potential or prevailing symptoms associated therewith. When free from all other abnormalities, a foot can be in balance only when it functions without prevailing pronation.

For the purpose of mutual understanding, the feet may be regarded as semimobile structures on and by which the superimposed weight of the body is propelled. The optimum relationship of osteo-articular structures in and related to the feet is maintained by the preservation of normal muscle function in walking.

In the order of normal weight-bearing, the foot has two divisions,—the heel and the midfoot. The forefoot is a mechanism essential to propulsion of the body; its weight-bearing function is secondary. These are simple facts which would not seem to require proof for acceptance. In the presence of doubt, there is an abundance of evidence to support each specific statement.

Moreover, it is obvious that such evidence must come from one or more methods devised to study the function of the foot in motion. Much may be learned by simple observation of successive individuals in groups representing known conditions. This was proved by Cross, Thomas, Golding-Bird, Walsham and Hughes, and others in the past century. The disadvantages of this method are revealed by limitations in the

powers of visualization, when applied to the analysis of function of the foot while the subject walks. These limitations result from the complexity of the act of walking, and are expressed both by errors of omission and of commission. In this respect, the study of gait as applied to the foot required the application of physical laws for more accurate knowledge, as was true with respect to cardiac function, to the function of the gastrointestinal tract, etc.

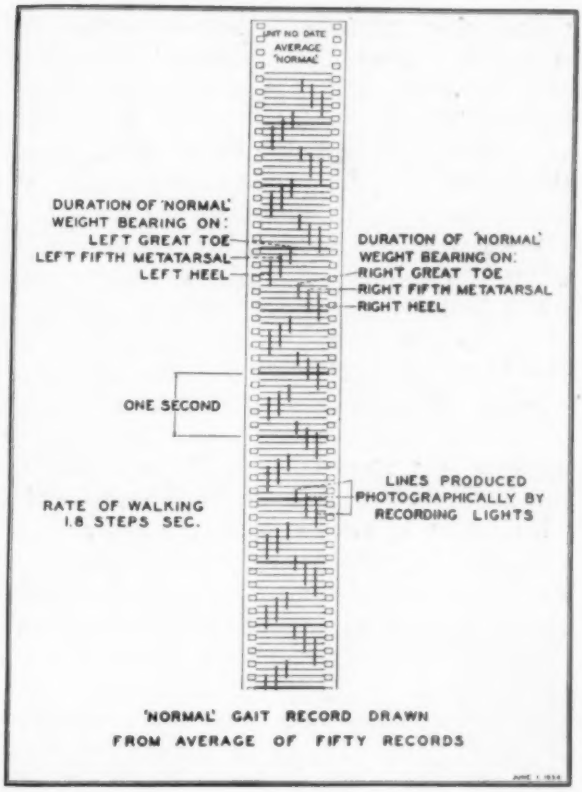
UNIT NO. DATE
AVERAGE 'NORMAL'
DURATION OF 'NORMAL' WEIGHT BEARING ON:
LEFT GREAT TOE
LEFT FIFTH METATARSAL
LEFT HEEL
DURATION OF 'NORMAL' WEIGHT BEARING ON:
RIGHT GREAT TOE
RIGHT FIFTH METATARSAL
RIGHT HEEL
ONE SECOND
LINES PRODUCED PHOTOGRAPHICALLY BY RECORDING LIGHTS
RATE OF WALKING 1.8 STEPS SEC.
'NORMAL' GAIT RECORD DRAWN FROM AVERAGE OF FIFTY RECORDS

FIG. 2

The principle of the electrobasograph has been previously described. The "electrical footprints" recorded by this instrument bear a close relationship to information essential for a better understanding of human locomotion.

The average record of normal gait is presented in Figure 2. It defines foot function in relation to three important time intervals: (1) the duration of time spent on the heel, the midfoot, and the forefoot; (2) the time sequence in which weight is received on the midfoot and on the forefoot; and (3) the time sequence in which weight is delivered from the heel to the midfoot, and from the midfoot to the forefoot. It must be evident that such recording of foot function to the thousandth of a second would also include the total duration of time for the stance phase, the period of double weight-bearing, the swing phase, and the period of overlap in weight-bearing on heel and forefoot in each step, as related to the respective feet. These measurements are essential to the academic understanding of human gait. It is true, moreover, that they become of equal importance to the solution of the common every-day problem of pronation.

To clarify these assertions, let us recall the prevailing structural relationships between the foot and the leg. The bones of the foot form a semimobile unit. Mortised between the malleoli, the astragalus articulates it with the tibia and the fibula. (Full consideration cannot now be

given to this complicated articulation of the ankle which is made to appear simple by its most obvious range of motion.) The posterior view of the skeleton reveals a disparity of alignment between the foot and the leg (Fig. 3).

The axis of weight-bearing of the tibia passes through the middle of the astragalus. The axis of weight-bearing of the os calcis is displaced laterally from one to one and five-tenths centimeters. Such malalignment between the tibia and the os calcis is normal. This, together with other commonly prevailing characteristics of the os calcis, provokes influences which further the instability between these strong and rigid bones.

At this point, it is desirable to omit the enumeration of each of the normally related influences which combine to make the foot an unstable osseous weight-bearing structure in relation to the tibia and the fibula. A more simple consideration may provide a better understanding of our subject. Let us visualize the bones of the foot and the leg which are united by the normal ligamentous capsules of the articulations. Under the influence of superincumbent weight, there is great distortion of contours from the normal definitions. These deviations from normal express a constant in one direction. The greatest evidence of change is naturally present where the foot is most mobile. This medioplantar deviation is most obviously related to the medial border of the foot at the level of the astragaloscaphoid joint. The end stage of deformity in this direction is illustrated in Figure 4.

FIG. 3

The malalignment of the weight-bearing axis of the tibia with that of the os calcis favors instability of the foot on the medial side. There is a difference here of 1.2 centimeters. (*Courtesy of The Physiotherapy Review.*)

Such evidence requires the presentation of facts which are of major importance. It has been conclusively demonstrated that normal foot contours are not retained by virtue of the shape of the bones and of the strength of the connecting ligamentous capsules. These demonstrations prove most conclu-

FIG. 4

Maximum deformity, structural flat-foot. There is a difference of 2 centimeters between the weight-bearing axis of the tibia and of the os calcis.

sively that the opposite statement is true. When the bones of the foot and the leg are joined only by their ligamentous capsules, their relationship is distorted in the weaker position of pronation when downward pressure is applied to the tibia.

In this respect, the bones of the foot structurally present a relationship to each other which favors instability in the direction of pronation. We cannot ignore indisputable evidence which claims the need for supporting structures essential for maintaining foot contours which are commonly regarded as normal.

Muscle and related tendinous structures, which function normally under voluntary control, prevent foot deformities which would otherwise be inevitable. We readily appreciate that muscle strength alone is less important than the question of balance in functional strength and mechanical advantage in groups of opposing muscles under voluntary function,—a fact of great importance.

Both intrinsic and extrinsic muscles with their respective tendons are the essential structures upon which the foot is completely dependent for balance in walking. Of these two, the extrinsic group has the predominant influence.

We are all familiar with the muscles forming this group. We can visualize their proportionate size and course in their respective positions on the posterior, lateral, anterior, and medial aspects of the leg.

The posterior group—the peronei and the tibialis posterior, which initiate plantar flexion, and the gastrocnemius and soleus, which lift the body weight—does the most work in normal walking. The antagonistic anterior group of muscles is much weaker. The gastrocnemius, in relation to its origin and insertion, frequently precludes the possibility of avoiding pronation when the subject walks without elevation of the heels. Moreover, the relationship of the tendo achillis to pronation becomes of particular importance because of the disparity in alignment between the os calcis and the tibia. The prevailing limitation in dorsiflexion, without pronation, while the knee is fully extended, is frequently associated with "contracture" of these posterior structures as a dominating cause. In such instances, treatment directed only at the medial aspect of the foot cannot by and in itself be effective. The muscles which control the medial and lateral aspects of the foot can never prevent pronation in the presence of these two causes,—malalignment of the weight-bearing axis of the os calcis, and "contracture" of the tendo achillis.

These extrinsic muscles of the leg send to the foot their strong tendons. Structurally, they are arranged to form a tendinous sling in which the bones of the foot are suspended. In fact, this is the only mechanism upon which the foot can depend for protection against the development of abnormal contours. The prevailing balance in the efficiency of normal muscle function determines the presence or absence of balance in the foot as related to pronation and associated functional strain. Moreover, this balance in muscle function must work against the inherent instability

FIG. 5

Medioplantar view of the tendinous sling. Tibialis anterior, tibialis posterior, flexor digitorum longus, flexor hallucis longus, and peroneus longus, from above down.

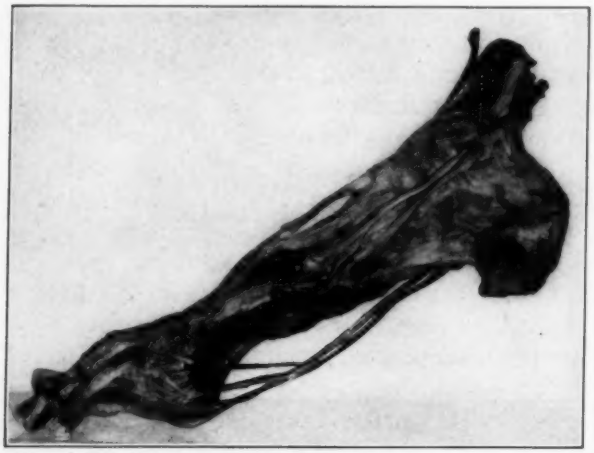

FIG. 6

Lateral view. Peroneus longus paralleled by the peroneus brevis which inserts on the cuboid.

resulting from the malalignment of the tibia and the os calcis, and the associated relationship of the gastrocnemius and the soleus, to which reference has already been made.

Dissections of the foot, revealing the course and insertions of these extrinsic muscles, present most clearly the tendinous sling that they provide for support to the bones and the articulations which they surround. The medioplantar view reveals, from above down, the tibialis anterior and the tibialis posterior which control the varus position of the forefoot and the midfoot respectively (Fig. 5). The flexor digitorum longus and flexor hallucis longus gain an effective leverage in passing from the posterior border of the internal malleolus to their respective insertions. The peroneus longus can be seen as it passes over the inferior surface of the cuboid anteriorly and medially to insert on the plantar surface of the base of the first metatarsal. The course and level of the insertion of the tibialis anterior and the peroneus longus make them true antagonists. The flexor digitorum longus and flexor hallucis longus are joined at the point of crossing. This union is of a particular character with relation to function. Contracture of the flexor hallucis longus is accompanied by flexion of the four lateral toes, due to this area of tendinous attachment. The converse is less true. Moving-picture records reveal that the great toe flexes only a little when flexion

of the four lateral toes results from a pull on the flexor digitorum longus.

The course of the peroneus longus from the posterior border of the external malleolus is paralleled by that of the peroneus brevis to the level of the cuboid where the latter is inserted, as revealed in the lateral view (Fig. 6).

Observation of this same dissection from the posteroplantar aspect combines these two views of the tendons which suspend the bones of the foot (Fig. 7). This additional evidence of their intimate relationship to the bones of the leg and the foot is most positive. *At present, however, the correlation of extrinsic tendons to bones of the leg and the foot is significant only in the relationship which it bears to function of the foot in balance.*

FIG. 7

Posteroplantar view combining that which is shown in Figs. 5 and 6 to reveal the tendinous sling provided by the strong intrinsic muscles to maintain normal foot contours.

At this point, it is essential to review the causes of abnormal balance which have been presented with evidence. The disparity in alignment between the weight-bearing axis of the tibia and the os calcis is a primary cause of pronation. The ligamentous capsules of the joints, particularly of the calcaneoscaphoid joint, cannot prevent the development of this or of any other abnormal relationship between the bones. The extrinsic muscles of the foot, through their tendons which suspend the bones of the foot, can prevent pronation only when their functional balance is efficient in counteracting the malrelationship normally existing between the tibia and the os calcis, and the other factors which favor instability.

The consideration of the treatment of pronation, therefore, must include consideration of all of these major factors. Acceptance of the premise, based upon the facts enumerated, and of the resulting conclusions directs attention to the foot and the leg as a unit. No reason need be given to justify the removal of the cause of any prevailing symptoms. In this instance, our premise indicates that both intrinsic osteo-articular and extrinsic musculotendinous influences combine to throw an apparently normal foot out of balance in walking. Treatment must, therefore, be directed toward these two causes.

These intrinsic osteo-articular and extrinsic musculotendinous structures may be defined and appreciation of their relationships may be acquired by the study of dissections, but there is still another requirement to be met. They must be visualized in motion while the foot and the leg are considered as a unit during the reflex act of walking. The electrobasographic records reduce the intricate and complex functional interrelationships to a common denominator, previously defined in terms of time intervals. These apply to each foot and are obtained while the subject walks at a natural, uninstructed rate.

TABLE I

HEEL-FOREFOOT OVERLAP

Foot	Street Shoes *Seconds*	Duty Shoes *Seconds*	Difference *Seconds*
Right	0.220	0.063	0.157
Left	0.189	0.048	0.141

TABLE II

PERCENTAGE OF TOTAL WEIGHT-BEARING TIME SPENT IN HEEL-FOREFOOT OVERLAP

Foot	Street Shoes *Per Cent.*	Duty Shoes *Per Cent.*	Difference *Per Cent.*
Right	34.3	9.8	24.5
Left	29.6	7.5	22.1

Through and in relation to all of this detail, we are still mindful of our objective. The more accurate definition of cause is essential to the most rational direction of treatment for any prevailing abnormality.

FIG. 8

In record W0162-4, the period of overlap in weight-bearing on heel and forefoot is indicated by the time interval between respective horizontal lines. Pronation was present. In record W0162-1, there was no overlap in relation to weight-bearing on heel and forefoot with duty shoes. *Pronation was absent.* (*Courtesy of The Physiotherapy Review.*)

Such accumulated records have brought much evidence to bear on the whole problem of human locomotion. Early in our work, it became apparent that balance of the foot was greatly influenced by the character of the shoes worn by the subject. Certain phases of these observations were later reported.

Further investigation warrants the belief that the extrinsic neuromuscular and tendinous structures, in association with all of the other structures which reflexively activate human locomotion, constitute an extremely delicate and sensitive mechanism.

This sensitivity is revealed in the presence of influences adverse to the foot's most efficient function. One common example of

FIG. 9-A

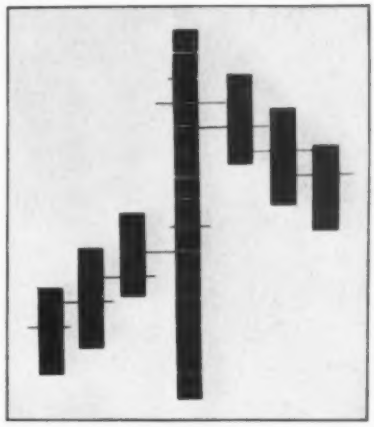

FIG. 9-B

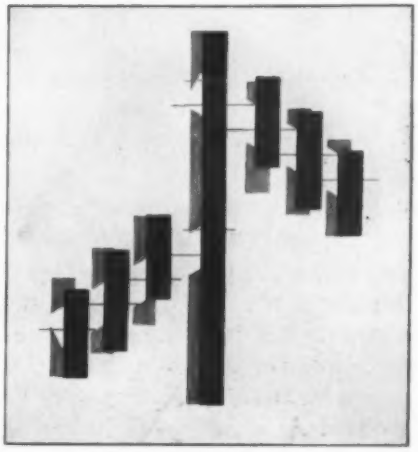

FIG. 9-C

Graphic presentation of averages for the gait records of twenty-four nurses. The middle bar represents 1.5 seconds. The heel, midfoot, and forefoot are represented on the respective sides (see normal record). Fig. 9-B (duty shoes) is superimposed on Fig. 9-A (street shoes) in Fig. 9-C. Note the heel-forefoot overlap in Fig. 9-A and the difference in distribution of weight-bearing in Fig. 9-B.

such influences is predominantly expressed in the relationship of shoes to feet. In many instances, shoes, made without regard for the natural and essential balance of the "normal" foot in walking, produce adverse influences beyond the natural power of compensation for their presence.

This important cause of imbalance was strikingly revealed in the records of twenty-four nurses. These were normal girls entering the training school at the average age of nineteen years. It seems reasonable to believe that they should have possessed the average ability to compensate for influences detrimental to normal balance of the foot while walking. Electrobasographic records were made while the subjects were wearing their own street shoes which they had brought from different cities. These shoes gave a fair average of conventional shoe design.

Immediately after the girls had removed their street shoes and had put on duty shoes, similar gait records were made. These duty shoes had been made in accordance with our analysis of the requirements for balance of the normal foot while walking.

Measurements taken from all of these records have given expression to averages. Enumeration of all of the various averages might be con-

FIG. 10

Heel meter for determining the correct heel-height of shoe for each individual.

fusing, and, if not, they would only confirm the results as expressed by the period of overlap in weight-bearing on the heel and the forefoot of the respective feet. Previous reference has been made to this period of the stance phase of normal human locomotion. It may be defined as the interval of time during which the heel and the forefoot are simultaneously in contact with the floor at any rate of walking.

As illustrated in Figure 8, Record W0162-4 represents the gait of one of the nurses while she was walking in her street shoes. The horizontal lines drawn across the respective steps reveal this period of overlap in weight-bearing on the heel and the forefoot. Under the influence of maximum pronation, there is no weight-bearing on the lateral border of the foot. A partial expression of this fact is revealed in this record. It is indicated by the short duration of weight-bearing time on the midfoot in certain steps. These street shoes had been made with reference only to the foot at rest, having no regard for the balance of the foot in motion. Like a weight which throws a revolving wheel out of balance, these conventional shoes hung on the feet of these nurses. They were a malinfluence, against which the normal reflex mechanism could not compensate for the expression of normal balance of the foot in the stance phase of gait.

Record W0162-1 in Figure 8 represents the gait of the same girl while walking in duty shoes which were constructed in Rochester. They were made to express principles essential to balance of the foot, as has been defined in relation to the stance phase of gait. Gadgets were not used in this work. The illustration is typical of the evidence which defines a difference in function when the foot is relieved from the malinfluence of conventional shoes. While the subject was walking in the duty shoes, there was little or no overlap in weight-bearing time on the heel and the forefoot. This one measurement proves that the prevailing degree of pronation present in the street shoes was absent in the duty shoes. The latter shoes did not inhibit the normal sequence of weight-bearing on the three areas of each foot. The stable lateral border of the foot received the body weight from the heel, leaving the forefoot free for the essential function of propulsion (Figs. 9-A, 9-B, and 9-C).

The total overlap in the duration of weight-bearing on heel and forefoot was averaged from the records made with these shoes. This time interval for the "normal" gait record (Fig. 2) was 13.8 per cent. (right) and 11.0 per cent. (left) of the total time for the stance phase of the respective steps. As these figures increase, we know that the foot is more pronated; therefore, more out of balance. The street shoes gave an average of 34.3 per cent. for the right heel-forefoot overlap and 29.6 per cent. for the left heel-forefoot overlap. The duty shoes gave an average of 9.8 per cent. for the right heel-forefoot overlap and 7.5 per cent. for the left heel-forefoot overlap in relation to the stance phase of the step. This is summarized in Tables I and II. In brief, the overlap between heel and forefoot was 24.5 per cent. and 22.1 per cent. longer with the right and the left street shoes than when the subjects walked in the duty shoes. Marked pronation was present in the former case and absent in the latter because the duty shoes were made to meet the requirements for balance of the foot in walking.

This evidence supports the statement made by Ellis in 1889: "Let the form of the boot-lasts correspond in shape to that of the *feet in action.* Then, as I believe, the foot may be clothed with every reasonable regard for function and elegance, and yet, attaining its highest development, be preserved in the fullness of strength and of beauty."

This opinion expressed at the ending of the nineteenth century reflected the statement recorded by John Cross in 1819: "It is to the muscles that the foot is indebted for its arch, as well as for the firmness of the step. It is from a deficiency of vigor in these muscles, that the foot ever becomes plain, and that the plain foot is so unfit for the journey."

SUMMARY

1. Pronation of the foot is defined in terms of the prevailing imbalance of the foot while walking.

2. This definition is made possible by electrobasographic records of gait.

3. Twenty-four girls were studied with reference to the influence of shoes on balance of the foot while walking. Pronation was present in each case when street shoes of conventional design were worn. It was absent when the subjects wore shoes made to provide for balance of foot function in the stance phase of the step.

4. In these records, prevailing pronation is revealed by the overlap in weight-bearing time on heel and forefoot.

5. Under the influence of conventional shoes, normal feet may pronate while walking. Pronation brings strain on the whole locomotor mechanism, not on the foot alone.

6. The same feet do not pronate when the subject walks in shoes made to meet the requirements for foot balance in the stance phase of walking.

7. Normal balance of function of the extrinsic muscles, which sup-

port the bones of the foot in a tendinous sling, is the mechanism essential for protection against pronation and resulting strain.

8. The treatment of pronation, therefore, requires that consideration be given to the foot and the leg as a unit. Only through shoes which provide balance for the foot in the stance phase of gait can we compensate for malalignment of the os calcis with the tibia and the common contractures expressed through the tendo achillis.

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TRIMALLEOLAR FRACTURES WITH DISLOCATION OF THE ASTRAGALUS

A Method of Reduction and Fixation *

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In trimalleolar fractures, when from one-fourth to two-thirds of the articular surface is involved in the fragment of the posterior malleolus, the reduction may be very simple, but the retention of the position is quite difficult because of the immediate recurrence of the deformity when traction is released. In such cases, the following method has been used, and in no case has it failed to maintain the reduction.

TECHNIQUE

After the usual preparation of the skin, a Steinmann pin is placed through the os calcis and the traction bow is applied. The operator then reduces the fracture by traction and manipulation, using the Steinmann pin as a lever. A leg plaster is applied from the toes to above the knee, incorporating the pin in the plaster. With the Steinmann pin the reduc-

FIG. 1

Case 1. Lateral view of the right ankle after second reduction.

FIG. 2

Case 1. Lateral view of the right ankle after reduction with a Steinmann pin.

* Read before the Associated Physicians of Long Island, October 22, 1935.
† Service of B. W. Seaman, M.D., and William L. Sneed, M.D.

FIG. 3

Case 3. Preoperative lateral view of the left ankle.

FIG. 4

Case 3. Postoperative lateral view of the left ankle.

tion is easily maintained until the plaster is set, when the traction bow is removed. The plaster is changed at the end of the third week and the pin is removed. Weight-bearing with the leg in plaster is begun at the end of the sixth week. Active motion and physiotherapy are begun at the end of the seventh week. The end result can be estimated in about four months from the date of injury. There is some permanent limitation of motion in almost all cases.

FIG. 5

Case 5. Preoperative lateral view of the right ankle.

FIG. 6

Case 5. Postoperative lateral view of the right ankle.

CASE REPORTS

CASE 1. J. W., white, male, aged thirty-nine, stepped into a hole and twisted his foot on August 26, 1932. Two attempts to reduce the fracture-dislocation were made before the patient was seen by the author on August 28, 1932. Another reduction was then done and the reduction was maintained according to the method described. Thirty-two months after the injury there was a complete range of motion in all directions.

This was the first case treated by this method.

FIG. 7-A FIG. 7-B

Case 6. Preoperative anteroposterior and lateral views of the left ankle.

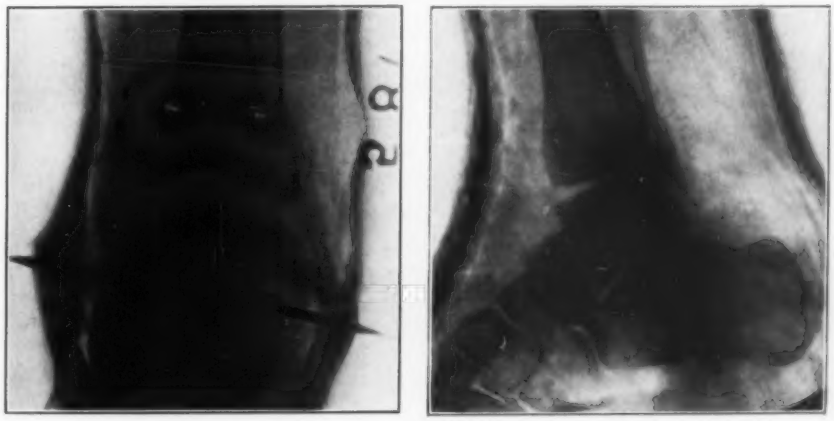

FIG. 8-A FIG. 8-B

Case 6. Postoperative anteroposterior and lateral views of the left ankle.

CASE 2. D. E., white, female, aged thirty-five, was struck by an automobile on September 23, 1933. Eighteen months after reduction dorsiflexion, inversion, and eversion were normal. Plantar flexion was limited.

CASE 3. J. H., white, female, aged fifty-eight, a diabetic, fell on her ankle on August 4, 1933. Twenty-one months after reduction dorsiflexion, inversion, and eversion were normal and plantar flexion was limited by about 10 degrees.

CASE 4. C. R., white, female, aged fifty-nine, fell down some steps on December 26, 1934. Seven months after reduction there was some widening of the ankle with thickening of the synovia. Inversion, eversion, and dorsiflexion were normal. Plantar flexion was limited by 5 degrees.

CASE 5. J. K., white, female, aged thirty-five, fell on the ice on January 29, 1935. The fracture-dislocation was reduced by another physician without success. Reduction was obtained by the author and maintained by the use of the Steinmann pin. Eight months after reduction dorsiflexion, inversion, and eversion were normal. Plantar flexion was limited.

CASE 6. A. M., white, female, aged fifty-six, twisted her ankle and fell on it on March 8, 1935. Seven months after reduction complete dorsiflexion, inversion, and eversion were present. Plantar flexion was limited by 5 degrees.

CASE 7. J. O., white, female, aged forty-four, was knocked down by a wave on July 14, 1934. Three months after reduction dorsiflexion, inversion, and eversion were normal. Plantar flexion was limited by 5 degrees.

SUMMARY

In the case reports two cases have been included that involved less than one-third of the articular surface and could have been reduced without the pin.

This method of maintaining reduction of a trimalleolar fracture with a posterior dislocation of the astragalus has been used for three and one-half years with complete success in all cases. The method is simple and easily executed. No open reductions have been necessary, and no recurrence of the deformity has resulted.

PERITENDINITIS CREPITANS

A Muscle-Effort Syndrome

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The affection variously called "crepitating tenosynovitis", "traumatic tenosynovitis", and "crepitating peritendinitis" is not commonly met with in the private practice of medicine, but is well known among industrial surgeons. Although this condition has been recognized for over a century and responds promptly to immobilization treatment, little has been known of the real morbid picture underlying the disease. The outstanding diagnostic sign of crepitation in the soft tissues on movement of the extremity or part is so bizarre and so singularly confined in pathological states to this one group of conditions that one's curiosity concerning the underlying intrinsic causes is easily aroused but far less easily satisfied.

The usual history given by a patient is that, after a long lay-off from work or shortly after a change from habitual work to an unfamiliar task requiring new and rapid movements, he has experienced aching soreness in a particular muscle group. Continuation of the same work gives rise to severe pain which may call for immediate cessation of activity, or the pain on arising prevents the patient's return to work and brings him to the physician for relief. In other instances, the pain of direct trauma by contusion to the arm, leg, or fingers is superseded, after hours or days of continued usual and accustomed exertions, by the crippling pain of crepitating peritendinitis.

On first examination, the patient presents a localized swelling of the forearm or leg, often with oedema, if in the lower extremity, and frequently with local heat and redness of the part. There is severe pain on movements of the limb, marked in those active movements initiated by the particular muscle group involved or by the passive movements which place those same tendons and muscles under the most tension and on the stretch. By careful study of active and passive movements that produce pain, one can identify each tendon and muscle involved. During such active and passive movements, the examiner's hand, placed over the swollen area and site of tenderness, feels a distinct, and often startling, crackling crepitus. On auscultation with a stethoscope, one hears an astonishingly loud and confusing series of crackles, crunches, and squeaks. Occasionally the patient may have a slight fever; never in the author's experience has the temperature risen above 99.4.

The particular site of local swelling, redness, local heat, tenderness, and crepitation is situated along a tendon or group of tendons, most frequently at or near the musculotendinous junction and never, in the writ-

TABLE I

FREQUENCY OF INVOLVEMENT OF MUSCLES IN THIRTY-TWO † CASES OF PERITENDINITIS CREPITANS *

Muscle	Cases
Extensor carpi radialis longus	15
Extensor carpi radialis brevis	15
Abductor pollicis longus	15
Extensor pollicis brevis	15
Extensor indicis proprius	5
Extensor pollicis longus	5
Tibialis anterior	4
Extensor hallucis longus	4
Flexor carpi radialis	3
Extensor digitorum communis	3
Extensor digitorum longus	2
Gastrocnemius	2
Peroneus longus	1
Peroneus brevis	1

† Since compilation of this table, two unusual cases have been observed,—one of a young lady in whom there was crepitating myositis of the right supraspinatus muscle, and the other of an active middle-aged man in whom similar symptoms occurred in the right biceps femoris muscle.

* Associated muscles were often simultaneously affected.

er's experience, in that part of the tendon supplied with a synovial sheath. If the muscle possesses a synovial sheath, the sheath proper shows no distention or tenderness, and crepitation is lacking over this area as well.

Careful study of a series of thirty-two cases of crepitating peritendinitis personally observed showed that eighteen patients suffered no direct trauma to the part involved; fourteen of these had either renewed previous employment after long lay-offs from work or had been given unfamiliar tasks involving repeated and rapid movements of particular muscle groups. Fourteen patients received contusions upon hand, arm, or leg, and continued to work from one to fourteen additional days at usual and accustomed toil before becoming incapacitated by the development of crepitating peritendinitis. Each of these fourteen patients had definite and unmistakable evidence of direct trauma in the form of a bruise (several with marked ecchymosis), small laceration, or abrasion to the part, and there can be no doubt that direct injury occurred.

By far the most frequent muscle group affected was that composed of two radiocarpal extensors, with simultaneous involvement of the abductor pollicis longus and extensor pollicis brevis. Simultaneous involvement of these four muscles and their tendons occurred in fifteen instances. The distribution of muscles and tendons involved in the thirty-two cases is shown in Table I.

Several writers have attempted to show that the disease is a metastatic form of bacterial infection, or a toxic manifestation of focal infection,

or is due to a gouty or rheumatic diathesis. In only one of these thirty-two cases could a definite and undoubted infectious connection be proved. This patient developed a furuncle on the dorsum of the left hand. His temperature was 99.4 by mouth. Incision of the boil (the patient continued to work) was followed five days later by crepitations along the extensor tendons of the hand and of the index finger to the midjoint. Two patients had small lacerations at the site of direct trauma, which showed no sign of active infection. A fourth patient had small cement burns on the arm. Only one patient was found who had a recent cold and upper respiratory infection. He was malnourished and had very carious teeth. In all the other patients, no active focus of systemic infection could be found. There were three patients who had slight fever in whom no cause for fever could be found other than the crepitating peritendinitis. The fever subsided and did not persist after effective immobilization of the part.

Since adequate explanation of the pathological nature of this illness was lacking, three patients were so cooperative as to allow exploration and biopsy to be carried out under local anaesthesia. These three cases deserve report in detail.

CASE REPORTS

CASE 1. J. J. R., male, aged thirty-two, a tire worker, had been unemployed for almost two years. One week after beginning work, which consisted of changing and repairing automobile tires, he began to notice pain on motions of the left wrist and thumb. While at work early one morning he was forcibly struck by a tool on the left forearm. He continued work for about two hours when he was forced to stop because of pain on motions of the left thumb and wrist. He was unable to lift with this hand and complained of a feeling of loss of power.

Examination showed a swelling of the dorsoradial aspect of the left wrist, beginning four centimeters above the radial styloid process and running seven centimeters toward the elbow. Slight local heat and redness were present. The area described was extremely tender to pressure. Abduction and extension of the thumb, as well as flexion and extension of the wrist, produced pain and crepitation in the swollen area. The crepitation was felt by the patient and was both felt and heard by the examiner without the stethoscope. Through the stethoscope the friction rub was almost deafening in intensity. The patient had no fever and had had no recent colds or respiratory infections, and no systemic foci of infection could be found.

Under local anaesthesia (.0075 per cent. novocain), injected *intracutaneously* so as not to obscure any underlying tissue appearances, the skin and subcutaneous tissues were incised over the swelling. The subcutaneous tissues were very vascular, and many fine, briskly bleeding points were encountered. The deep fascia was transparent, tense, and bulging. At incision of the aponeurosis, translucent, gray, oedematous tissue bulged under considerable tension and was with difficulty identified as perimysial areolar tissue overlying the muscle. The muscle was dark and cyanotic in appearance. No fibrin was seen. The tendons of the extensor carpi radialis longus and of the extensor carpi radialis brevis were exposed radial to the thumb muscles by separating the thumb muscles by sharp dissection. The tendons of the extensor pollicis brevis and of the abductor pollicis longus took their origin from the deep surface of the muscle belly, while the radial extensors arose on the superficial surface of their muscles. Normally, between the two sets of tendons, areolar tissue interposes, but in this instance there was a clear, clean space free from fluid and gross fibrin. The tendons of the extensor pollicis brevis and of the

abductor pollicis longus lay upon and in contact with the radial extensors. At the lower border of this area, the reduplicated folds of tendon sheath, uninjected and containing no fluid, could be seen about the radial extensors. The tendons of the radiocarpal extensors were yellow and turgid, and showed tiny, fine, wavelike corrugations on their surface.

Voluntary motion of the thumb and of the carpal extensors was present, and the palpating finger detected intensive crepitation transmitted through muscle belly and tendon. No bleeding was encountered beneath the deep fascia; the perimysium and peritenon contained fine vessels. When tissues from over the muscle-tendon junction were removed, no bleeding occurred. Cultures of the wound were sterile.

Paraffin sections revealed extreme oedema with spreading apart of fibers of connective tissue, fibrillation of elastic fibers, small areas of interstitial hemorrhage, and red static thrombosis of the venules. Small arterioles showed margination by leukocytes. There were scattered areas of plasma-cell and round-cell infiltration. Interstitial deposits of fibrin were found in granular form, as well as in clumps and in masses.

Case 2. F. S., male, aged forty, a laborer, had been employed steadily for over a year. Four days before reporting for treatment he had begun to use a single jack hammer for breaking concrete with a cold chisel. Following two days of this work, the right forearm had become sore. The patient continued at his work part of the time, using the air-compression hammer the last day and a half. Increasing pain and difficulty in using the right hand and wrist forced him to stop work in the middle of the afternoon. He denied direct injury by blow or by strain. There was no history of recent colds or of upper respiratory infection.

Examination showed a ruddy-cheeked, well-developed Swedish laborer, whose right lower forearm was swollen on the dorsoradial aspect. Local heat and marked tenderness were noted, but there was no redness of the area. The swelling began five centimeters above the radial styloid process and extended to twelve centimeters from the wrist. Movements of the thumb and wrist, passive or active, evoked extreme pain, and gross crepitation could be felt by the examining hand and heard with the stethoscope. Active dorsiflexion of the wrist and extension and abduction of the thumb against resistance were painful, and these movements were markedly diminished in strength as well. If the thumb was held rigid, movements of the distal phalanx were painless. The patient's temperature was 99.4. No foci of infection were found on careful examination.

Exploratory operation was carried out after intradermal infiltration of 1-per-cent. novocain without adrenalin. The subcutaneous tissues contained many fine, briskly bleeding vessels. On incision of the deep fascia, the underlying tissues bulged out under the tension of the translucent oedematous tissue, so transparent that one could see tiny vessels coursing through the jellylike oedematous tissue to the depth of over one-half an inch. In most of these vessels, the blood could not be stripped along with the handle of the scalpel. The tissues oozed a clear, slightly straw-tinged fluid. The muscle near the tendon junction of the abductor pollicis longus and the extensor pollicis brevis was soggy, oedematous, and dark purplish-red in color. The abductor muscle retained the finger impression and scarcely any voluntary contraction was present. This muscle did not contract when a small piece was excised for biopsy. The short thumb extensor had a greater power of voluntary contraction and contracted sluggishly when its fibers were cut. Careful sharp dissection separated the muscle bellies and, on retraction, one could see their tendons arising on the deep surface of the muscle. Beneath this muscle was a free space unlined by synovia. The floor was formed by the radiocarpal extensor tendons which arise on the superficial surface of their muscles. The tendon surfaces were stained yellow and showed tiny, fine, wavelike corrugations on their surfaces, apparently either fibrin deposits or areolar-tissue strands. Near the distal lower depths of the wound one could see the reduplicated folds of synovial sheaths which were not tense or bulging with fluid.

Specimens for biopsy were taken of the oedematous areolar tissue of the peritenon and perimysium above and beneath the thumb muscles and from the bellies of the two thumb muscles themselves. These four specimens were placed in separate tubes of ster-

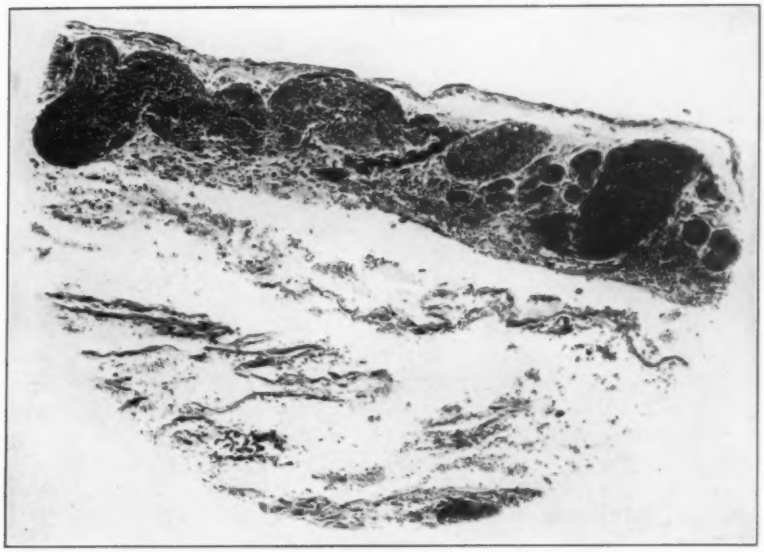

FIG. 1

Low-power photomicrograph (× 80). Hematoxylin-eosin stain. Thrombosis of the venules in the peritenon and perimysium with oedema of the surrounding areolar tissue. Extravasations of red blood cells can be seen in the lower portion of the specimen.

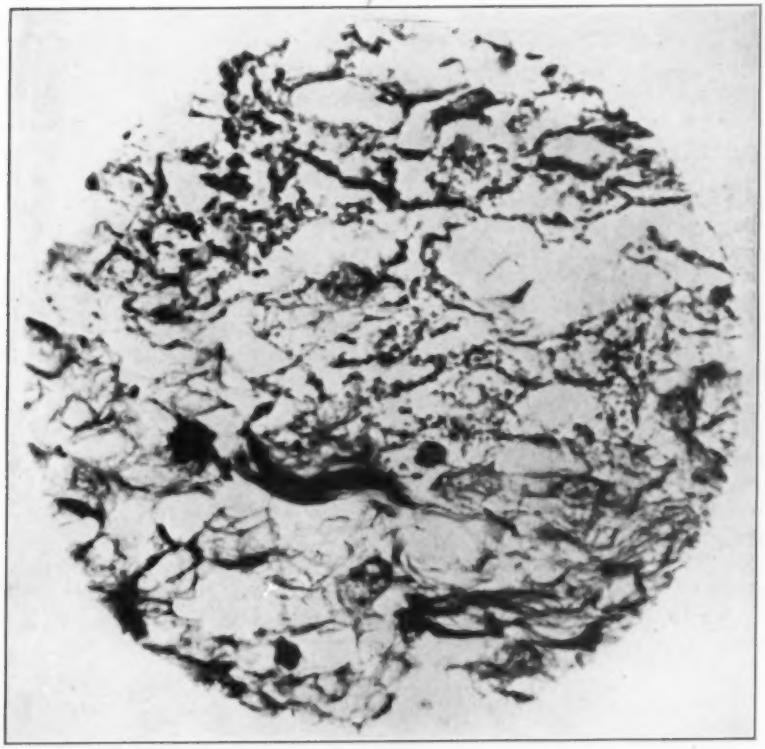

FIG. 2

High-power photomicrograph (× 120). Weigert's fibrin stain. Oedematous areolar tissue with granular deposits of fibrin in rosarylike chains.

FIG. 3

Photomicrograph (× 80). Weigert's fibrin stain. Solid clumps of interstitial deposits of fibrin in the oedematous areolar tissue about the muscle.

ile cold normal saline, covered with sterile mineral oil, and taken to the laboratory for study of hydrogen-ion concentration and for miscroscopic section. With the help and kindness of Dr. Maurice Tainter of the Department of Pharmacology of the Stanford University Medical School, the writer is able to report the figures obtained.

With the use of the Michaelis series, standard colorimeter set for determination of the hydrogen-ion concentration and with paranitrophenol as the final indicator, the following pH values * were secured: abductor pollicis longus, 6.55; extensor pollicis brevis, 6.38; peritenon and perimysium superficial to the muscle-tendon junction, 6.30; similar tissue beneath the muscle-tendon junction, 6.30.

The tissues were immediately placed in 95-per-cent. alcohol, and paraffin sections were prepared from the fixed tissue and stained with special stains. The saline extracts remaining were positive for lactic acid with the ferric-chloride test. Cultures of the wound itself showed no pathogenic bacteria.

Microscopic sections stained for glycogen failed to show glycogen in the muscle substance of the abductor pollicis longus, while the extensor pollicis brevis showed small quantities infrequently collected between the sarcolemma and the sarcoplasm in the better preserved muscle areas. Sections were further stained with hematoxylin-eosin, van Gieson's stain, phosphotungstic acid, Mallory's stain, and Weigert's fibrin stain. The muscle fibers showed fragmentation in many places. The fibers of the abductor muscles had lost their cross striations and were swollen and hyaline, with frequent splitting apart of sarcostyles, and with occasional liquefactive necrosis. Everywhere the sarcoplasm was separated from the sheath by oedema. Both hemorrhage and fibrin deposits were seen in the oedematous endomysial fibrous tissue. Local areas of static thrombosis of venules, with infrequent sparse round-cell and plasma-cell infiltration were seen in the endomysium. In the oedematous areolar tissue of the peritenon and perimysium were red thrombi and deposits of fibrin in granular form as well as in large clumps and in masses.

* The errors and difficulties encountered in accurately estimating tissue pH values by the colorimetric method are well known. Glass-electrode intravital pH readings would be of great value in checking the reliability of these colorimetric findings.

CASE 3. S. L., male, aged twenty-one, who had been unemployed for over a year, began stacking crates of empty beer bottles in a warehouse. He stood on the floor tossing crates to the workman above, who piled and stacked. The work was fast and lasted only two days. On the afternoon of the second day, he noticed pain, swelling, and a creaking sensation over the lower left forearm. There was no history of a direct blow or of a bruise. No further work was available, but the left forearm continued to be sore and tender. Five days later he reported to the Out-Patient Clinic of the Lane Hospital. There was no history of a recent cold or of infection.

At physical examination the temperature was found to be normal. There was a fusiform swelling over the dorsoradial distal one-fourth of the left forearm. The swelling began five centimeters above the radial styloid process and reached its maximum nine centimeters above the styloid process. There was no local heat, but the skin was slightly reddened. The area was tender to pressure and, on movements of the wrist or thumb, crepitation could be felt with the hand, and loud crackles and crunching sounds were heard through the stethoscope. Radial dorsiflexion against resistance and active abduction or extension of the thumb gave rise to the greatest pain. No foci of infection could be found. The patient gave a history of a similar condition in the anterior shin muscles of both legs during training for track in four successive years in high school and in junior college.

An exploratory incision was carried out after the skin had been anaesthetized with intracutaneous injection of 1-per-cent. novocain. The subcutaneous vessels bled briskly

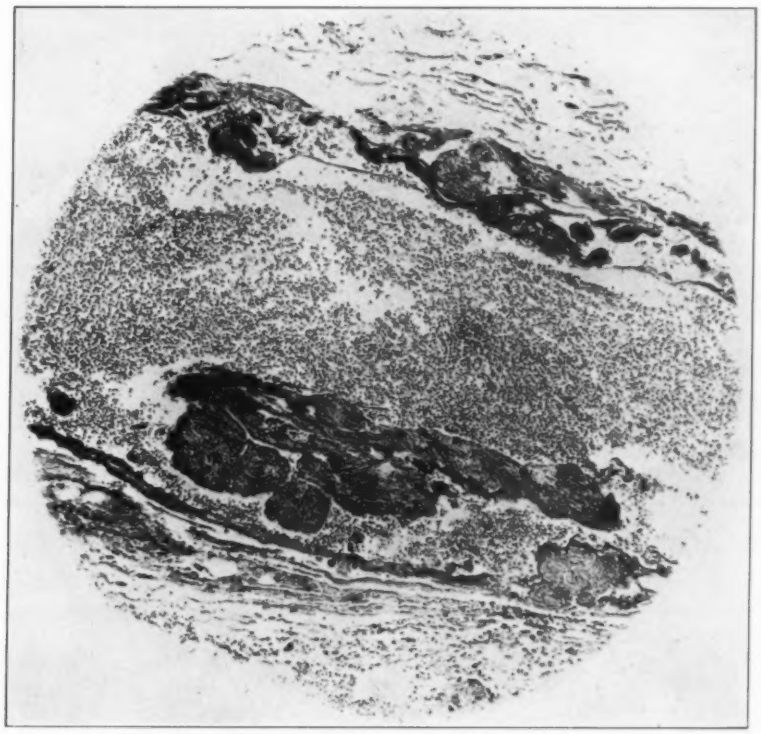

FIG. 4

Photomicrograph (× 80). Hematoxylin-eosin stain. Large masses of fibrin lining and bordering a blood-filled hemorrhagic area of peritenon. The fibrin masses were apparently formed by continued motion with progressive agglomeration of finer fibrin clumps and granules.

at many fine points. The deep fascia was tense and transparent and when it was excised the underlying tissues bulged into the wound. The overlying perimysium was oedematous, clear, and jellylike and oozed a faint straw-tinged fluid. Fine blood vessels could be seen coursing through the transparent tissue and the blood could be stripped along the vessels with difficulty. Both the abductor pollicis longus and the extensor pollicis brevis contracted voluntarily. In color, they were dark red, bordering on a purplish tint. When voluntary or passive movements of the thumb or of the wrist were made, very distinct crepitation could be felt in the muscle and only faintly in the tendon. The muscle bellies were carefully separated and, on elevation and retraction, their tendons were seen to arise on the deep surface of the muscle. Between the thumb muscles and the underlying radiocarpal extensor tendons was oedematous areolar tissue of peritenon, through which could be seen the yellow-tinged tendons. The muscle at the tendon junction of the radiocarpal extensors was dark and oedematous, and the tendons arose on the superficial surface of the muscle.

Cultures of the wound depth were sterile. Specimens for biopsy were taken of the two thumb muscles, which contracted briskly when cut, and of the perimysium superficial to the muscle and peritenon beneath. These were separately placed in cold sterile normal saline, covered with oil, and taken to the laboratory, and the hydrogen-ion concentration was determined in the same manner as before, using paranitrophenol as the indicator. The estimated pH of the abductor pollicis longus was 6.0; of the extensor pollicis brevis, 5.9; of the tissue above the muscle, 5.9; and of the tissue beneath the muscle, 6.0.

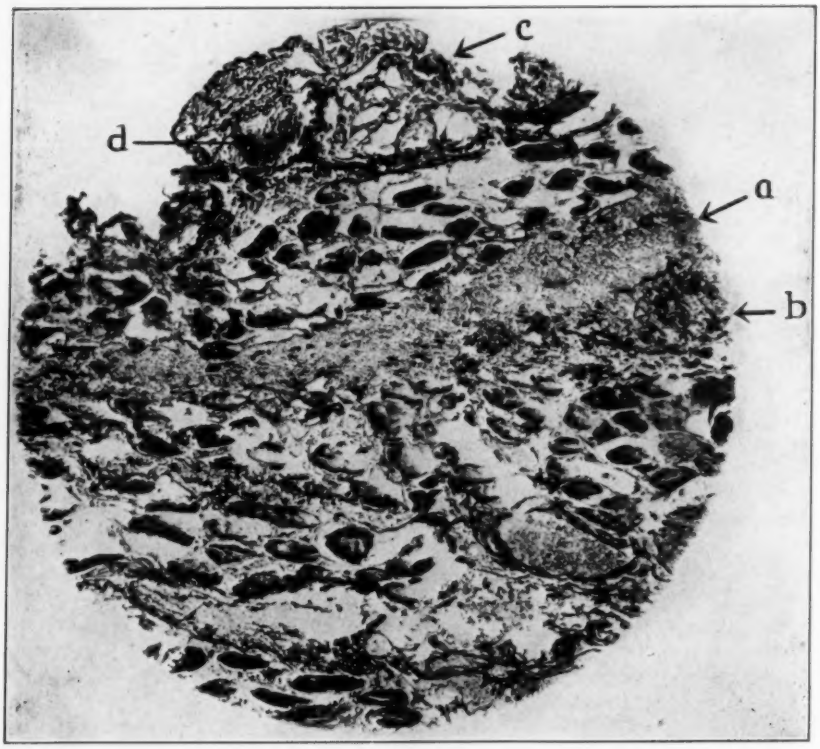

FIG. 5

Photomicrograph (× 80). Mallory's stain. Interstitial hemorrhage of endomysium (*a*). Marked oedema with clear halo separating sarcoplasm from sarcolemma about individual muscle fibers. Liquefactive degeneration and necrosis of muscle fibers present. Fibrin deposits at *b*, *c*, and *d*.

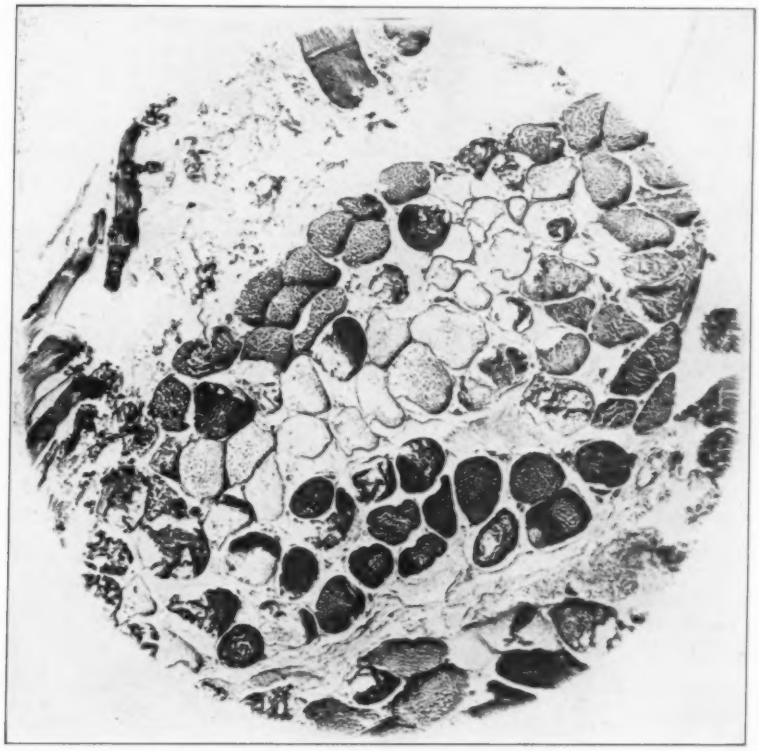

FIG. 6

Photomicrograph (× 80). Hematoxylin-eosin stain. Oedema of endomysium. Liquefactive necrosis of muscle fibers.

Again the residual saline extract was positive for lactic acid when tested with ferric chloride.

Microscopic paraffin sections showed that the muscle glycogen was depleted. Only small crescents between the sarcoplasm and the sheath still stained for glycogen. The muscle fibers were fibrillated, the cross striation was often lost, and many areas showed liquefaction of muscle fibers, although the sheath remained. Many small red and hyaline thrombi were seen in the endomysial fibrous tissue. Frequent cross fracture of muscle fibers with retraction of the fiber in the sheath could be made out. Frequently, the sarcostyles of the muscle fiber could be seen split apart and fibrillated. The sheath was frequently separated from the sarcoplasm by oedema. There were focal hemorrhages in the muscle bundles, with areas of fibrin deposit between the fibrous tissue spread apart by hemorrhage. The perimysium showed venous sinusoids occluded by red and hyaline thrombi. Marked oedema split apart the structure of the fibrous tissue and focal small and large hemorrhagic areas were seen. Fibrin deposits in clumps, in granular form, and in larger masses could be made out. Scattered infiltration of plasma cells, of round cells, and of clasmatocytes were seen.

DISCUSSION

These operative and laboratory findings are significant. The gross appearance of the tissues on operative exposure is as unusual as the crepitation on clinical examination of the part. These facts (*i.e.*, clear jellylike oedema of the areolar tissue about muscle and tendon, dark-

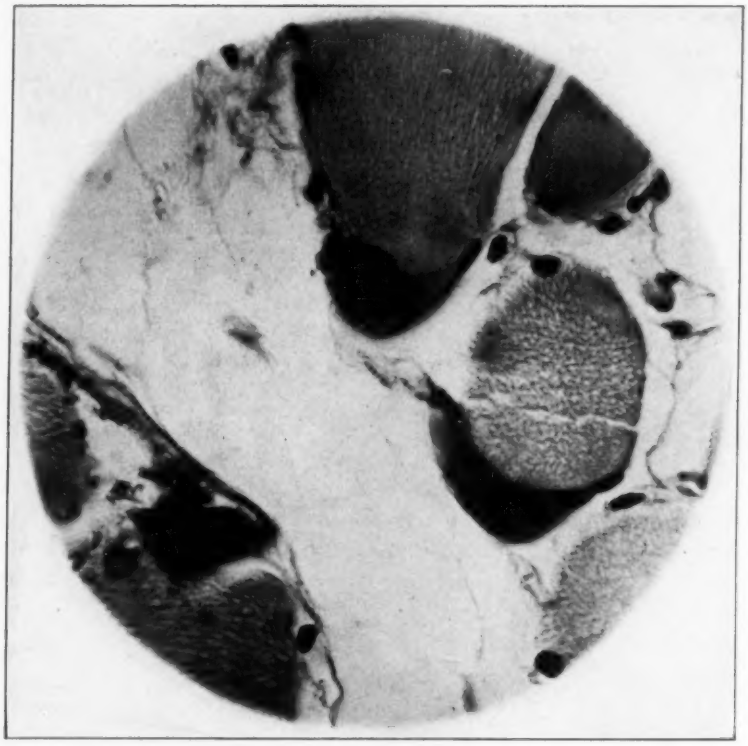

FIG. 7

Photomicrograph (× 220). Best's carmine stain for glycogen. Oedema of muscle and endomysium. About the better preserved muscle are crescents of fluid between the sarcolemma and the sarcoplasm, which takes glycogen stain.

colored muscle which may be lacking in voluntary contractile power and, on histological examination, shows muscle-fiber lysis or destruction, hemorrhage interstitially in muscle and areolar tissue, thrombosis of venules and interstitial fibrin deposit, loss of muscle glycogen, and the relatively acid pH value found in the tissues, extracts of which are positive for lactic acid) all bear out the clinical impression that the condition arises through fatigue and exhaustion of definite muscle groups rather than through metastatic bacillary inflammation from foci of infection or from vague and shadowy "toxic conditions". In every one of the thirty-two cases, excessive and unusual activity or usual activity following direct trauma had taken place.

While only three patients were subjected to operation, the site and distribution of swelling, of tenderness, and of crepitation never coincided with the extent and boundaries of normal tendon sheaths. In the patients upon whom operations were performed the tendon sheaths were seen to be uninvolved and beyond the pathologically changed area.

Since Velpeau first described tenosynovitis sicca in 1818, the condition has been ascribed to overexertion and to the fatigue resulting from

unaccustomed work. Boyer stated that the condition was not a "synovitis sicca", since the swelling, tenderness, and crepitation lay outside of the tendon sheaths, and gave it the name of "*cellulite peritendineuse*". Almost without exception, the standard text-books and the hand-books of surgery still refer to the disease as a tenosynovitis. It was not until 1909 that von Frisch took specimens for biopsy from tissue about the tendons of the thumb muscles in two cases. He noted the serous oedema and marked congestion of the blood vessels of the peritendinous areolar tissue and found the tendons unchanged grossly. Troell, in 1918, reported a carefully studied series of cases and took pains to reproduce outline drawings of the anatomical extent of tenderness, swelling, and crepitation, which showed them invariably to be beyond the area of synovial sheaths. In addition, he cited instances, as did Velpeau, of the involvement of muscles and tendons which normally have no sheaths. The tendo achillis, the triceps brachii, the pronator teres, the vastus lateralis, and the rhomboidei have all been described as sites of this disorder. Troell, from his clinical studies and from the biopsies reported by von Frisch, established the name "peritendinitis crepitans". Hauck added a further instance of biopsy in a single case involving the tendons of the dorsal thumb muscles.

The experimental approach has been applied to this disease by Oblenskaja and Goljanitzki, who observed 189 cases of serous tenosynovitis among 700 tea packers in a Moscow tea factory over a period of eight months. These workers make between 7,500 and 12,000 estimated movements of the hands a day. In the experimental work done by these authors, enforced alternate movements of extension and of flexion of the hind leg of a rabbit were carried out by means of an electric motor at the rate of 18,000 to the hour. In one hour no change was observed, but in two hours oedema of the peritendinous and perimuscular tissues was present, while in six hours the tendon sheaths and joint cavities were full of fluid. Histological examination was not reported, and crepitations were not described. Moritsch and Blau used exhaustion through faradization over the tendo achillis of the rabbit to study the problem. Two rabbits, faradized in this manner for ten minutes daily for one month, showed no gross changes in the tendons of the hind legs. With previous doses of typhoid vaccine, daily faradization of the tendo achillis for six days gave rise to adhesive inflammation between the skin, the peritendinous tissues, and the surrounding tendons and muscles. Similar experiments, using intravenous injections of virulent streptococci, followed by faradization, produced similar changes. No crepitus was felt or heard and no microscopic studies were carried out. These authors felt that peritendinitis crepitans is a metastatic manifestation of a chronic focal infection, of rheumatism, or of acute upper respiratory infections, the site of metastasis being determined by trauma.

From the present studies, it is evident that the primary pathological change is probably in the muscle, through exhaustion by continued and

unremitting unaccustomed toil, in which use is made of a particular muscle group with friction of tendon on tendon, unprotected by synovial sheath or by bursae overlying bony prominences, and, by direct external trauma to the part, thrombosis of blood vessels of the peritenon and of the perimysium occurs. Whether lactic-acid retention precedes thrombosis of venules is not known. At all events, with thrombosis of venules, lactic-acid retention occurs, oedema appears, hemorrhage in areolar tissue and muscle takes place, fibrin is deposited in the oedematous tissues, and crepitation clinically appears. Exhaustion of the muscle is accompanied by depletion of muscle glycogen, and, in the advanced cases, liquefactive changes appear; in the less advanced cases, fibrillation and fracture of muscle sarcoplasm can be seen, as well as loss of cross striation, hyaline changes, and oedema.

Finally, if one can by this means show acute gross and microscopic changes through exertion of internal muscle forces alone, what rôle may we attribute to the constant and repeated unremitting minor traumatic and mechanical insults of body motion and exercise in the degenerative diseases of the locomotor apparatus of the body? Meyer has already pointed the way in his careful studies of attritional changes in human joints, of the tendon of the long head of the biceps brachii, of the supraspinatus tendon, and of the phenomena called by him "polishing of bony surfaces".

TREATMENT

Treatment has not been improved upon since Velpeau advised rest and immobilization of the part, using a starched crinoline bandage for this purpose. All too common an error is the use of a splint which ineffectively immobilizes the muscles and tendons involved. The failure to include the thumb in cases of involvement of the forearm is a frequent mistake. Immediate relief is obtained by the use of an effective unpadded plaster splint, and in those cases in which there is slight fever the temperature returns to normal. The thirty-two patients whose cases are reported in this study averaged ten and one-half days' disability. In two instances, insufficient immobilization prolonged the disability to twenty-two and thirty days. The various forms of heat, massage, and motion bring no relief and have no place in the treatment of this affliction; they serve only to prolong disability. Elastic compression or adhesive strapping is useless except in the mildest cases. It is highly important to recognize and to practice as well as to teach these concepts, since every standard text-book and system of surgery in the English language, as well as most of those published in German, advise rest, but with massage and early motion, as well as the application of heat in its various forms.

CONCLUSIONS

1. Peritendinitis crepitans is the result of exhaustion of particular muscle groups by unaccustomed and unremitting toil, or by continued, usual, accustomed labor following direct trauma.

2. Pathologically it is characterized by glycogen depletion of muscle, acute degenerative muscle changes, thrombosis of venules, retention of lactic acid, oedema, and local increase in pH to a relatively high acid reaction. Interstitial deposits of masses and of clumps of fibrin give rise to the distinct diagnostic clinical sign of crepitation in the soft parts involved.

3. The primary change is without doubt in the muscle, the other factors developing secondary to muscle exhaustion.

4. The disease is not connected with the synovial tendon sheaths, and is not a "synovitis sicca".

5. Adequate, complete immobilization of joints and portions of the extremity moved by the affected muscles and tendons is the logical and most effective treatment. Baking, heat, massage, elastic compression, or strapping are makeshifts and are utilized without a true understanding of the pathological changes existing.

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AVULSION FRACTURE OF THE TIBIAL ATTACHMENTS OF THE CRUCIAL LIGAMENTS

Treatment by Operative Reduction

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A critical analysis of the generally accepted methods of treating avulsion fractures of the tibial attachments of the crucial ligaments shows clearly their impracticability. Reduction cannot be accomplished by such treatment as manipulating the leg into extension and immobilizing it in this position, since in extension the anterior crucial ligament is taut and hence lifts the fragment from its tibial bed. The alternative method of removing the broken fragment operatively is likewise unsatisfactory, in that it leaves the crucial ligament at loose ends, with consequent impairment of the stability of the knee joint.

Although for many years sporadic articles have appeared in the literature calling attention to the futility of the generally recognized treatment, but little progress has been made in developing a satisfactory method of reduction. Attempts on the part of the writer to devise a method that would insure reduction and retention of the fragment have led to the evolvement of the operative technique to be described. The method is proving practicable and has given consistently good results in a small series of cases.

OPERATIVE TECHNIQUE OF REDUCTION OF AVULSION FRACTURES OF THE ATTACHMENT OF THE ANTERIOR CRUCIAL LIGAMENT

Figure 1 shows a typical avulsion fracture of the attachment of the anterior crucial ligament. In reducing this fracture, the knee is flexed at a right angle and an Esmarch bandage is applied to the upper leg.

An incision is then made over the inner aspect of the knee joint. It begins at a point corresponding to the attachment of the vastus muscle to the quadriceps tendon, curves around the patella about one-half an inch away from it, runs along the inner margin of the patellar tendon, and terminates one inch below the attachment of the patellar tendon. The fascia and synovia are incised. The patella is displaced outward.

The periosteum on the medial aspect of the tibia is separated for a distance of one inch below the margin of the tibia and is retracted. Curettage of the blood clot in the cavity left by the fragment is carefully carried out.

Both menisci are carefully inspected. If damaged, they are removed in their entirety. Special instruments (Fig. 2) are used for this purpose, which make it possible to follow around the condyles of the tuberosities

of the tibia and to free the cartilages without damage to the joint surfaces.

Two drill holes are made from the anterior surface of the tibia to the fracture cavity, beginning medial to the attachment of the patellar tendon and three-quarters of an inch below the margin of the tibia. These drill holes may converge slightly at the lower end to facilitate tying the suture knot. The drills should emerge at the edges of the fragment, or slightly to the outside of the edges, so that when the fragment is pulled into its bed it will not be held up by the suture.

If the fragment is of sufficient size and comes far enough forward, a drill hole may be made through it, but care must be taken to avoid splitting the fragment.

All bone dust should be carefully removed from the drilled areas.

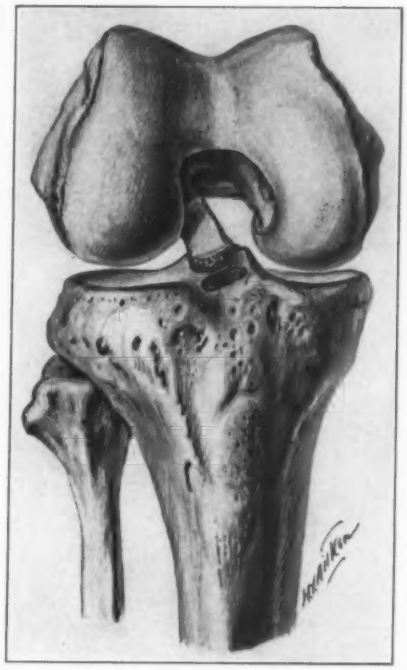

FIG. 1

Avulsion fracture of the attachment of the anterior crucial ligament.

A double suture is passed through one drill hole in the tibia; it is then drawn through the drill hole in the fragment, or, in the absence of this channel, through the anterior crucial ligament at its attachment into the bone; and it is finally brought down through the other drill hole in the tibia to the outside where it is tied. (See Figure 3.)

If, upon reduction, the crucial ligament is found to be unusually lax, it may be tightened by moving the frag-

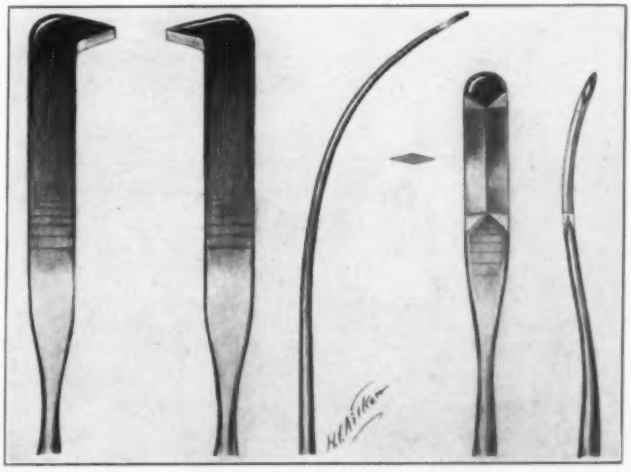

FIG. 2

Special instruments used to facilitate the removal of the menisci. The hooked instrument makes freeing of the cartilage easy, and the instrument with the double cutting edges permits freeing of the cartilage at its posterior attachment without damage to the joint surfaces.

FIG. 3

Operative reduction of an avulsion fracture of the attachment of the anterior crucial ligament.

ment forward. This is made possible by shaving the edges of the cavity to enlarge it anteriorly.

The wound is closed in the usual manner.

Special attention should be given to the bandaging after operation in order to obtain the maximum amount of compression. Sheet wadding, one and one-half inches thick, is first applied and then compression is obtained with a flannel bandage. The Esmarch bandage is removed.

A posterior plaster-of-Paris shell is applied with the knee in about 25 degrees of flexion. Immobilization is continued for from five to six weeks. Baking, massage, and passive movements are then carried out, care being taken to force complete extension, which is the last motion to return.

CASE REPORTS

CASE 1. W. B., male, aged fifteen years, injured the right knee in a fall from a bicycle.

Roentgenographic examination showed a fracture of the spinous attachment of the anterior crucial ligament extending into the inner tubercle. The fragment was of the large size usually seen in these fractures in children and showed a tendency to displace laterally. There also appeared to be a crack through the fragment posteriorly. (See Figures 4-A and 4-B.)

Operative reduction, according to the technique described, was carried out six days after the injury. Damage to the external meniscus necessitated its removal.

End Result: One year after the operation, the knee is painless, stable, and has a full range of motion.

CASE 2. R. W., male, aged ten years, injured the right knee in a fall from a horse.

Roentgenographic examination showed a fracture of the anterior tubercle of the tibial spine. The fragment was long and narrow and hinged posteriorly. (See Figure 5.)

Operative reduction, according to the technique described, was carried out two days after the injury.

End Result: Two and a half years after the operation the knee is painless, stable, and has a full range of motion. (See Figures 6-A and 6-B.)

CASE 3. Mrs. H. W., aged thirty-seven years, injured the right knee in a fall. The knee locked in about 20 degrees of flexion. For two weeks the patient did not consult a physician and continued to limp about on the leg.

Roentgenographic examination, which was first made two weeks after the injury, showed a fracture of the anterior tubercle of the tibial spine. Arthritic changes were present around the inner condyle of the femur.

Operative reduction was immediately carried out according to the technique de-

scribed. When the joint was opened, an area was seen on the inner condyle of the femur where the cartilage was worn away, apparently from arthritic irritation.

End Result: Four and a half years after the operation the knee is stable, painless, and has complete function. There is, however, some catching in the joint, and the roentgenogram (Fig. 7) shows marked ridging on the margin of the femoral condyle, which is the result of the irritative arthritic process and possibly of damage to the condyle at the time of injury. As yet, the patient has not suffered from these changes.

CASE 4. J. S., male, aged forty-five years, was hit on the knee by an automobile.

Roentgenographic examination revealed a large fragment, with the anterior crucial ligament attached, lying between the condyles. It had been torn from the internal tibial spine.

Operative reduction, according to the technique described, was carried out three days after the injury.

End Result: One year and three months after the operation, the knee is stable, painless, and has complete function.

OPERATIVE TECHNIQUE OF REDUCTION OF AVULSION FRACTURES OF THE ATTACHMENT OF THE POSTERIOR CRUCIAL LIGAMENT

Figure 8 shows a typical avulsion fracture of the attachment of the posterior crucial ligament. During the reduction of this fracture, the patient lies on his face with the leg extended. No tourniquet is applied.

An incision is made over the popliteal space, in the midline. By separation of the gastrocnemius at its point of bifurcation, excellent

FIG. 4-A

Case 1. Anteroposterior roentgenogram before operation, showing fracture extending into the inner tubercle of the tibial spine and a crack through the fragment posteriorly, with deviation of the fragment to the outer side.

FIG. 4-B

Case 1. Lateral roentgenogram before operation. Note the large size of the fragment and the displacement caused by the attachment of the crucial ligament when the knee is in 15 degrees of flexion.

FIG. 5

Case 2. Lateral roentgenogram before operative reduction, showing the long, narrow fragment, hinged posteriorly.

FIG. 6-A

Case 2. Anteroposterior roentgenogram taken two and one-half years after reduction.

FIG. 6-B

Lateral roentgenogram taken two and one-half years after reduction.

exposure is obtained. The artery, veins, and nerves are retracted laterally.

In the two cases treated by the writer a hole was found in the posterior capsule of the joint, through which the fragment was visible and palpable.

A suture is passed through the ligament above the small bony fragment, and the fragment is pulled down to as near its original site as possible. The suture is attached to the capsular tissue, which is thick in this area.

The defect in the capsular tissue is repaired. The wound is closed tightly.

A plaster-of-Paris dressing is applied with the knee in 15 degrees of flexion, a position that relieves the tension posteriorly and thereby permits better healing of the skin.

At the end of four weeks, passive motion is begun. By the time that the position of full flexion is obtained, the attachment of the crucial ligament is sufficiently solid to allow weight-bearing. Recovery is usually complete within six weeks.

FIG. 7

Case 3. Lateral roentgenogram taken four and one-half years after operative reduction, showing the attachment of the crucial ligament in position. Irritative changes in the femoral condyle are due to damage at the time of injury and to an arthritic process.

CASE REPORTS

CASE 5. Mrs. R. C., aged sixteen years, was sitting in an automobile when it was struck head on by another car. The patient was hurled through the side of the car and landed against the truck before falling to the ground. The force of the impact was taken on the upper tibia, as evidenced by a contusion.

Physical examination showed no lateral instability, but posterior laxity was present to the extent that the tibia could be displaced three-quarters of an inch. Roentgenographic examination (Fig. 9) revealed a fracture on the posterior aspect of the tibia.

Operative reduction, according to the technique described, was carried out four days after the injury.

End Result: Seven years after the operation, the knee is absolutely stable. The range of motion is normal. The scar is not adherent. (See Figure 10.)

CASE 6. C. M., male, aged twenty-three years, was cranking a truck that was in gear, with his heels braced against the sill of the garage, when the truck jumped forward and bumped the tibiae several times. The truck finally stalled and its bumper pinned

FIG. 8

An avulsion fracture of the tibial attachment of the posterior crucial ligament.

the patient against the garage for three and a half hours before he was rescued.

Physical examination of the right leg revealed that, with the knee fully extended, there was laxity which allowed 15 degrees of knock-knee and approximately three-quarters of an inch of posterior subluxation of the tibia. The leg was most comfortable in extension.

Roentgenographic examination showed an avulsion fracture at the tibial attachment of the posterior crucial ligament with separation of the fragment.

Operative reduction, according to the technique described, was carried out seven days after the accident.

End Result: Five months after the operation, the knee is stable, painless, and has a full range of motion.

DISCUSSION OF LITERATURE ON OPERATIVE REDUCTION

Pringle, in 1907, was the first to suture the tibial spine to the tibia after its avulsion and he published one case in which the result was successful. Following this report, isolated cases of suture of the fragment appeared in the literature (Christopher; Leriche and de Girardier; Simon; and Roth). Several writers (Moorhead; Swett, McPherson, and Pike; Costa; Courty; Goetjes; Matti; Caan; and Allen), without reporting cases, commented on the impracticability of the accepted methods. In all these methods, with the exception of those of Simon and Caan, the manner of suturing the fragment may be questioned. Screws and nails were used in a few instances, thereby introducing into the joint a metallic substance. In other cases the fragment was supposedly sutured to the periosteum of the tibia. It may be possible at times to attach the fragment to the cartilage fibers or to the periosteum of the tibia, but as a rule these tissues provide no satisfactory means of attachment. Roth found that, if the fragment was held in position with forceps until the leg had been extended, the condyles then tended to hold it. Good results were obtained from the use of Roth's method, but it would appear that the fragments in his cases must have been unusually large in order for the condyles to fix them in position. In the average case the condyles do not touch the fragment, and, without any means of fixation, the pull of the ligament and the continued oozing of blood force the fragment upward.

The most satisfactory means of suturing the fragment has been suggested by Caan and Simon; the former reported no cases, but the latter carried out the procedure successfully in two cases. In principle these

FIG. 9

Case 5. Lateral roentgenogram showing an avulsion fracture of the tibial attachment of the posterior crucial ligament.

FIG. 10

Case 5. Lateral roentgenogram, taken seven years after operative reduction, showing the attachment of the posterior crucial ligament in position.

operations are similar to that of the writer, although neither Caan's nor Simon's work was known to the writer until he was reviewing the literature in preparation for this paper. The operative procedure of these writers consists of carrying sutures from the fractured surface through drill holes that lead obliquely to the anterior surface of the tibia, where the sutures are tied.

CONCLUSIONS

The operative technique described insures both reduction of the fragment and preservation of the crucial ligament in cases of avulsion fractures of the tibial attachment of the anterior or posterior crucial ligament. The method represents a decided advance in the treatment of these fractures, since by the general methods of treatment reduction is not possible and the stabilizing strength of the crucial ligament is lost.

Thus far, the technique has been carried out in four cases of fracture of the anterior crucial ligament and in two cases of avulsion of the tibial

attachment of the posterior crucial ligament. The results have been entirely satisfactory, and the patients have obtained stable, painless joints with a full range of motion.

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A TECHNIQUE FOR LESSENING HEMORRHAGE IN OPERATIONS ON THE SPINE

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Operations upon the spine usually induce hemorrhages which are difficult to control. The hemorrhage masks the field of operation and prolongs and complicates a difficult procedure. This paper presents a simplification for the subperiosteal exposure of the posterior portion of the spine. The technique was developed in 1924 by animal experimentation. Since then it has been used many times upon man by the author and by his colleagues.

ANATOMY

The profuse arterial hemorrhage, so frequently encountered in operations upon the posterior spine, results from disruption of the internal muscular branches of the dorsal divisions of the lumbar and thoracic arteries. Figure I shows how closely these arteries approximate the lateral surfaces of the spinous processes. These arteries are so deeply embedded in the spinal-muscle masses that they cannot be seen. Their avoidance is possible only through an intimate knowledge of the muscles in which they lie.

In Figure 2 is shown the cross-sectional relationship of these muscles at different levels of the spinal column.

The posterior spinal muscles may be regarded as two large muscle bulks lying in bony grooves, one on either side of the posterior midline of the vertebral column. These muscles are divided, functionally and anatomically, into three layers: a superficial, a middle, and a deep layer.

It is necessary to determine the origin and insertion of the several muscles in each of the three layers. Figure 3 shows the course and direction of the fibers of each of the muscles comprising the posterior spinal-muscle groups.

Study of this diagram shows that

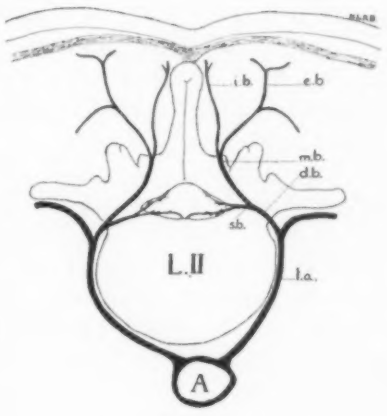

FIG. 1

Course of arteries supplying the posterior spinal muscles:
L.II = second lumbar vertebra
A = aorta
l.a. = lumbar artery
d.b. = dorsal division of lumbar artery
s.b. = spinal division of lumbar artery
m.b. = muscular branch of dorsal division
i.b. = internal muscular branch
e.b. = external muscular branch

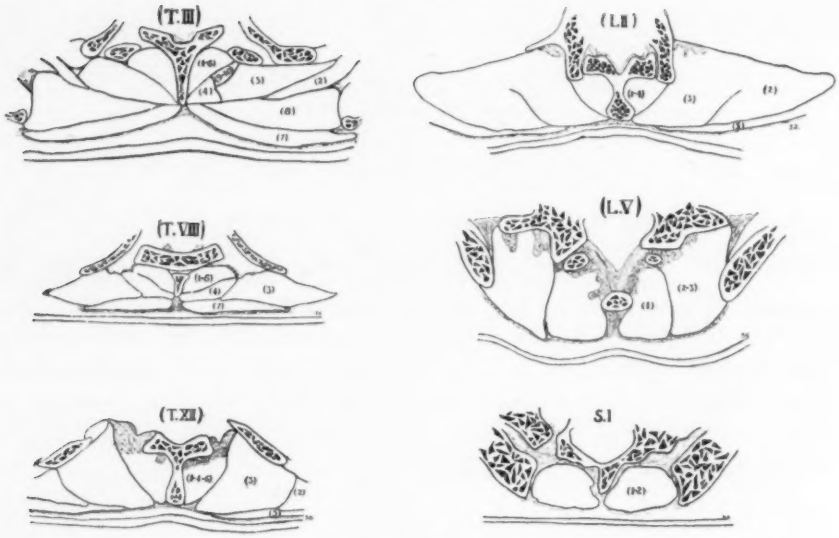

FIG. 2

Relations of the posterior spinal muscles as seen in cross-sections at various levels (adapted from "A Cross-Section Anatomy" [2]):

1 = multifidus
2 = iliocostalis
3 = longissimus dorsi
4 = spinalis dorsi
5 = latissimus dorsi
6 = semispinalis dorsi
7 = trapezius
8 = rhomboideus major
9 = longissimus cervicis
10 = longissimus capitis

in the superficial layer the muscle fibers of the lumbar area course upward and outward, having for the most part arisen centrally. In the thoracic area the majority of the superficial muscles arise laterally and their fibers pass upward and inward.

In both the middle and the deep layers the muscles of the lumbar, thoracic, and cervical areas arise laterally and pass upward and inward.

The bulk of the posterior spinal muscles can be regarded as arising from the transverse and mammillary processes and inserting at a higher level on the lateral walls of the spinous processes and into the interspinous ligaments. It is the recognition and utilization of this arrangement which makes possible the bloodless exposure of the spinal column.

TECHNIQUE

With the patient prone, an incision is made down to the deep fascia. Bleeding points are clamped and ligated. The skin and subcutaneous tissues are freed by blunt dissection from the deep fascia for a distance of approximately three centimeters on either side of the midline.

The lowermost limit of the desired exposure is determined and the spinous process at this point is located. The superspinous ligament, extending from this spinous process to the next higher process, is palpated. The scalpel is inserted in the midline between the two spinous processes and the superspinous and interspinous ligaments joining these processes

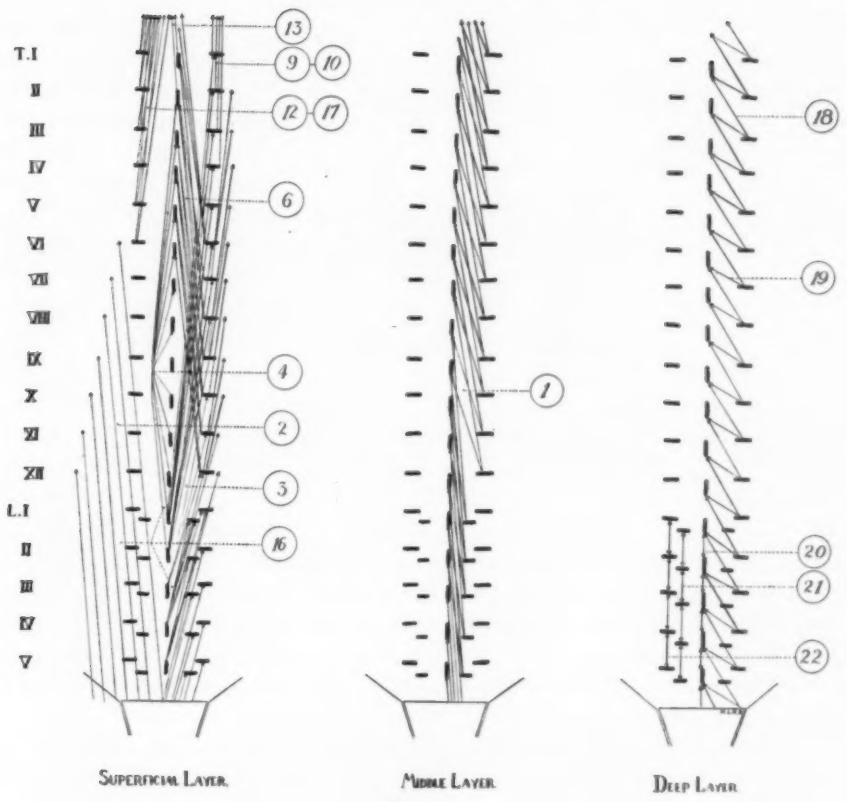

FIG. 3

Diagram showing the lines of pull of the fibers and the relative position and extent of the muscles which lie in the posterior vertebral grooves. The origin of the fibers is indicated by the tail, the insertion by the head of the arrows. The arrows extending outside of the groove represent fibers which insert on the ribs, but originate inside of the groove. The vertical rows of dashes represent the spinous processes of the vertebrae; the outer transverse rows, the transverse processes; and the inner transverse rows in the lumbar region, the mammillary and accessory processes. (After Braus, Piersol, and Spalteholz.)

Key to muscles:

1 = multifidus
2 = iliocostalis
3 = longissimus dorsi
4 = spinalis dorsi
6 = semispinalis dorsi
9 = longissimus cervicis
10 = longissimus capitis
12 = semispinalis capitis
13 = spinalis cervicis
16 = erector spinae
17 = semispinalis cervicis
18 = rotatores longi
19 = rotatores breves
20 = interspinales
21 = intertransversales mediales
22 = intertransversales laterales

are divided longitudinally. The knife is carried vertically downward to the base of the spinous process. In the slit thus made, a straight, blunt periosteal elevator is inserted. The lower tip of this instrument is forced outward and upward until it rests against the base of the upper spinous process. (See Figure 4.)

The lower end of the elevator is held firmly against the lamina, and the exposed end of the elevator is displaced laterally. By this manipulation, the muscle fibers inserting on the upper spinous process are made taut.

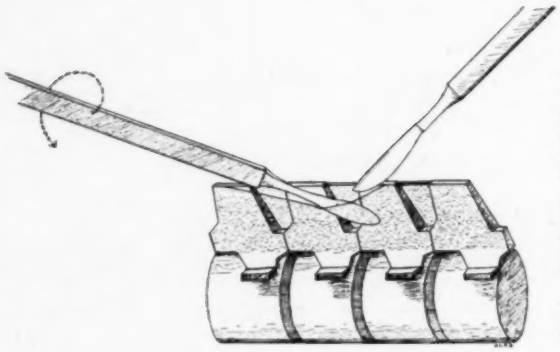

FIG. 4

Method of freeing the posterior spinal muscles from their insertions on the lateral walls of the spinous processes and to the interspinous ligaments. (The tip of the periosteal elevator should be shown held against *the base* of the spinous process.)

The taut fibers are cut from their insertion to the lateral wall of the upper spinous process. Great care is taken to free the muscle insertions subperiosteally from the spinous process and to split the interspinous ligament exactly in the midline.

When the muscle attachments are freed from one spinous process and interspinous ligament, the periosteal elevator is removed. It is then reinserted in a similar position against the base of the next higher process. This procedure is repeated until the central insertions of the posterior spinal muscles on one side of the column are freed through the desired length.

The muscles on the opposite side of the spinal column are freed in the same manner.

After the central insertions of the posterior spinal muscles on both sides have been severed, the muscles are displaced laterally by blunt dissection and retraction.

By means of this procedure, the posterior aspect of the spinal column can be exposed without encountering arterial hemorrhage. Some oozing of blood will take place from the denuded bony surfaces, but it will be insignificant in amount.

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CHANGES IN THE UPPER HUMERAL EPIPHYSIS FOLLOWING OPERATION FOR OBSTETRICAL PARALYSIS

Report of Two Cases

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In 1924 Kleinberg described an operation for the correction of the internal-rotation deformity of obstetrical paralysis of the upper arm. In this early report, an arthrodesis of the shoulder was done also. Later, in 1932, he reported ten cases, in eight of which the internal-rotation deformity had been corrected by reattachment of the joint capsule and external rotators. In these eight cases, the simple reattachment operation was done without the accompanying shoulder arthrodesis previously reported. The operation, as described by Kleinberg, consisted in the subperiosteal detachment of the joint capsule and insertion of the internal and external rotators in the upper one and one-half inches of the humerus. After these structures had been freed, the arm was rotated externally and the lateral flap was sutured more medially and allowed to overlap the medial flap.

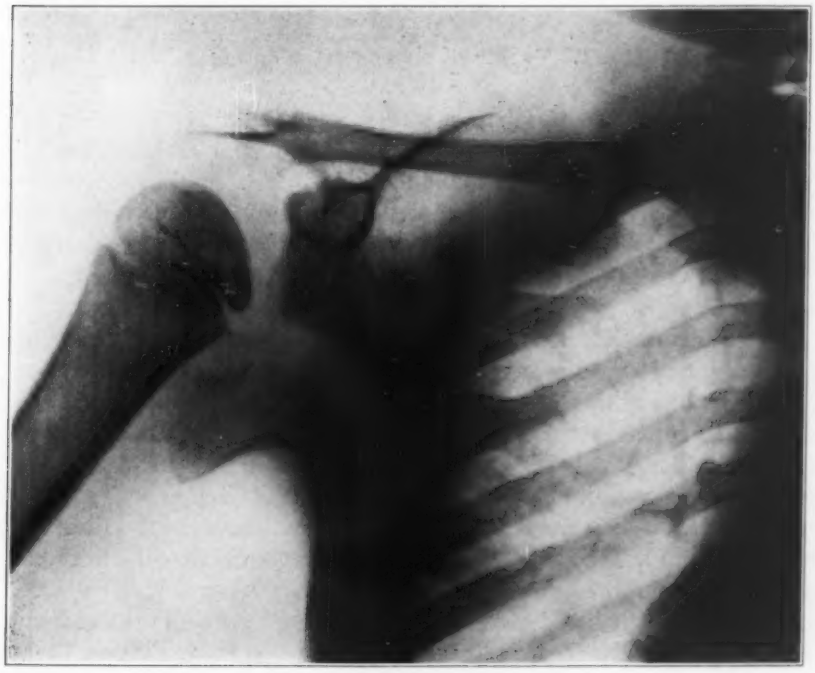

Fig. 1

Case 1. Before operation, June 1933.

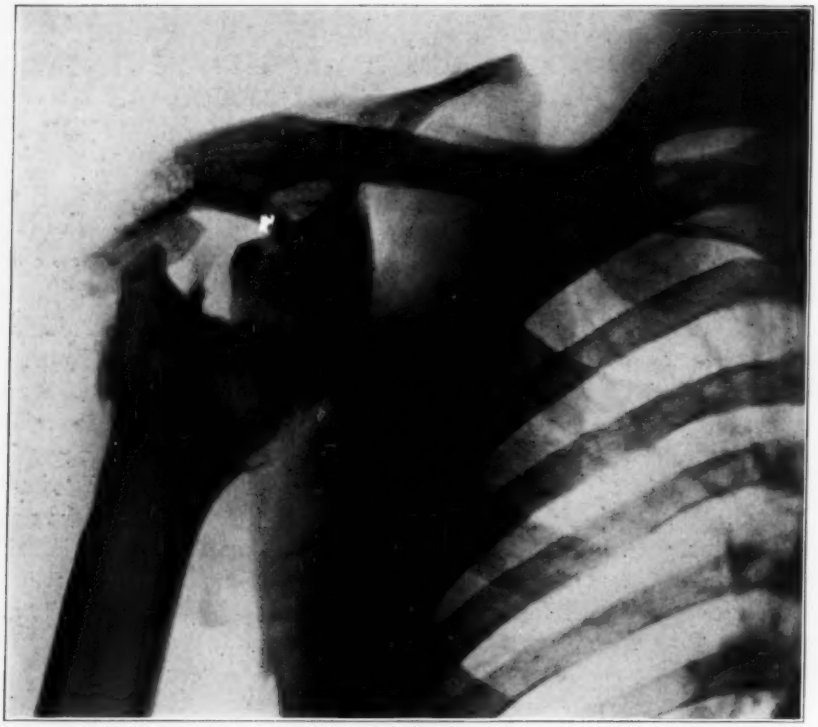

FIG. 2
Case 1. Twenty-eight months after operation.

In the last several months, the author has observed two cases in which operation had been performed for the internal-rotation deformity incident to obstetrical paralysis of the upper arm. The patients had been operated upon by different surgeons, but the technique described in the operative notes was essentially the same. Kleinberg's method for the reattachment of the external rotators had been used. In each case, good correction had been obtained at the time of operation and a position of full external rotation was maintained. For several months after operation, the progress seemed good and there was marked improvement in the position of the extremity and an increased range of motion in the shoulder joint. Each of these patients returned, however, complaining of stiffness in the shoulder joint and loss of function. The first returned after a period of twenty-eight months and the second after a period of twenty-four months. The corrected position had been maintained. Roentgenograms (Figs. 2 and 3) showed some significant findings. In both, there were changes in the upper humeral epiphyses with deformity and irregularity in density. It occurred to the author that these changes might be explained on a basis of vascular disturbance to the epiphysis, because, in the operation for reattachment of the external rotators, the capsule and periosteum over the upper one and one-half inches of the humerus are

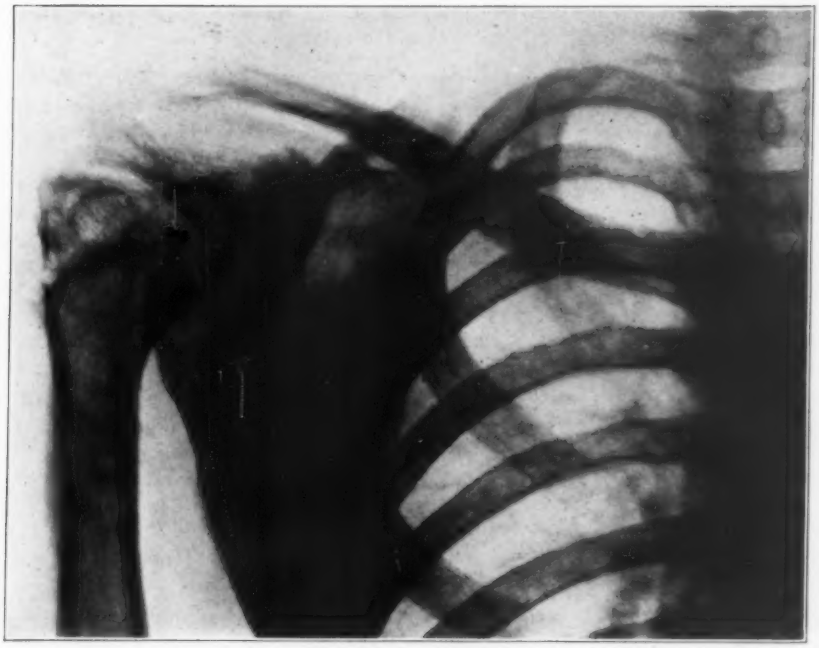

FIG. 3
Case 2. Two years after operation.

raised. This would account for the interruption of a major portion of the vascular supply to the epiphysis. The evolution of the change is indefinite as periodic roentgenograms were not available.

Reports of the cases of these two patients follow.

CASE 1. A male patient, aged twelve years, was seen first on April 4, 1932. The complaint was deformity and poor use of the right hand.

Examination revealed elevation of the right scapula with a marked fixed internal-rotation deformity of the shoulder joint, a flexion deformity of the elbow, and a pronation deformity of the forearm. Abduction was markedly limited and most of the abduction was scapular movement. The birth history was not remarkable, but it was recalled that at the age of three months the child had not used his right arm and that the wrist had been held in a flexed position. An abduction arm splint had been applied and worn for three months, which produced improvement. No other treatment had been administered.

A diagnosis of obstetrical paralysis of the upper arm was made.

A roentgenogram (Fig. 1) showed some deformity about the scapula and a normal upper humeral epiphysis. The shoulder was operated upon on June 22, 1933, and the capsule and external rotators were reattached after the technique of Kleinberg. The humerus was rotated externally and the new position was maintained in plaster. A fairly good functional result had been obtained by September 30, 1933.

The patient was seen again on February 1, 1935, twenty-eight months later. His complaint was inability to get his hand into his pocket. Examination revealed a good functional position. There was, however, practically no motion in the shoulder joint, and motion in internal rotation was insufficient to permit putting the hand into the pocket. A roentgenogram (Fig. 2) showed almost complete absence of the humeral

head with marked deformity of the remaining part. Subsequently, a partial arthroplasty produced considerable improvement in the range of motion.

CASE 2. A male patient, aged ten years, was first seen on June 1, 1933. Poor use of the right arm had been present since birth. History of the birth revealed a prolonged, difficult labor; the baby weighed nine and one-half pounds. Treatment had consisted in massage and manipulations.

Examination revealed that the right arm was much smaller than the left. There was an internal-rotation contracture at the shoulder, a flexion contracture at the elbow, and a pronation contracture in the forearm. The muscles acting about the hand and wrist were good. The extensors at the elbow were fair. There were no sensory changes.

A diagnosis of obstetrical paralysis of the upper arm was made. The patient was operated upon on June 8, 1933, and reattachment of the capsule and external rotators was done. Good external rotation was accomplished and the position was maintained in plaster. Function improved and a good position was obtained, but examination two years later revealed loss of function with stiffness about the shoulder and limitation in abduction. A roentgenogram (Fig. 3) showed deformity of the upper humeral epiphysis with irregularity in density. Preoperative roentgenograms were not available. Subsequent operation for muscle release improved the function slightly.

NOTE: The author is indebted to Dr. James A. Dickson, Cleveland, and to Dr. W. B. Carrell, Dallas, for permission to report these cases.

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FRACTURES AND DISLOCATIONS OF THE CERVICAL SPINE

Part II. Dislocations, Complications, and Operative Treatment

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GENERAL CONSIDERATIONS *

From the anatomy of the atlas and the axis it is reasonable to suppose that dislocation between them can take place without fracture. The articular facets are nearly horizontal, and a sheering or twisting force meets with no bone resistance except the odontoid. This is confirmed both clinically and roentgenographically. Complete dislocation in the lower cervical spine rarely occurs without a fracture. However, an incomplete unilateral dislocation—one in which the articular facet on one side rides up and forward on its mate below without slipping off—can occur without fracture. The articular facets become more and more vertical as they progress down the cervical spine and any complete dislocation, even if unilateral, is usually accompanied by at least a minor fracture. In ten out of nineteen cases of dislocation demonstrable fractures accompanied the other injuries. In other cases they were suspected, but not proved. In one case of complete bilateral dislocation between the fifth and the sixth vertebrae (Case 23), there was no visible fracture either in the roentgenogram or at open operation. It is the author's belief that this case was decidedly an exception to the rule.

Diagnosis

Diagnosis is made on a history of injury, on the presence of pain and tenderness in the involved region, and on the characteristic position in which the head is usually held. The injury is usually a fairly severe one, but occasionally a case is seen which has resulted from comparatively minor trauma. For instance, a little girl (Case 31), while skipping rope, turned her head to call a playmate and experienced a sudden pain in her neck. Roentgenograms showed that this sudden unguarded movement had produced a complete unilateral dislocation. Certain cases of "spontaneous" dislocation of the atlas on the axis have been reported, [1, 2, 3] usually associated with an acute infection of the tonsils or of the mastoids. These undoubtedly occur, but, except for one case (Case 37), which may or may not have been of this type, they are outside the field of this discussion which is confined to the strictly traumatic lesions.

The position in which the head is held is quite constant, and usually gives the clue as to the type of injury that has occurred. If there is a complete dislocation on the right, the head will be turned to the left and

* In Part I of this paper fractures of the cervical spine were discussed. Some of the general considerations under that heading, particularly the section on examination and preliminary care, are also applicable to dislocations.

tilted to the right. The reason for this position is clear when we consider the anatomy of the dislocation. First, assuming that we are still dealing with a dislocation on the right, the articular process of the upper vertebra rides forward on the process of the vertebra below. This riding forward upon the right turns the head to the left. When the dislocation is complete, the upper right articular process slips forward off of the one below and drops down in front of it; this downward slip gives the head a tilt to the right. If the dislocation is incomplete, the turning of the head is present, but there is little if any tilting. In cases of bilateral complete dislocation, the head is tipped forward without rotation. Although the position of the head is characteristic of cervical dislocation, it must not be supposed that it is pathognomonic of the condition. The position of "torticollis", the head turned to one side and tipped to the other, occurs in cases of myositis, of ligamentous strain, of cervical adenitis, or in any condition that may send the muscles of one side of the neck, particularly the sternomastoid, into spasm. A diagnosis of dislocation of the cervical spine may be suspected from the position of the head, but cannot be made on that sign alone. The differential diagnosis between fracture and dislocation must depend finally upon the roentgenogram. When a positive diagnosis of dislocation has been made on physical and roentgenographic evidence, the position of the head gives valuable information as to the extent and the location of the injury.

FIG. 1

Position of operator and patient during the reduction of a dislocation of the cervical spine.

Treatment

Treatment consists of immediate reduction of the dislocation, followed by plaster fixation. If the dislocation is incomplete, reduction is simple. Hyperextension and traction alone are sufficient. Three cases (Cases 21, 30, and 32) were successfully treated in this way. Usually traction for twenty-four hours with a pull of five pounds relaxes muscle spasm and restores normal relationships. When the dislocation is complete, reduction must be attempted only under anaesthesia. If the anaesthetist is acquainted with the nature of the case, the administration of an anaesthetic is not a dangerous procedure (anaesthetics were safely administered seventeen times in thirteen cases of this series). Traction in such cases is futile. No amount of direct pull will unlock the articular facets. Manipulation is necessary. The method used in this series of cases is that described by Walton in 1904. This has successfully stood the test of thirty years. Based as it is upon correct mechanical principles and

thorough understanding of anatomy, it is one of the finest examples of clear, logical theory borne out by practical experience.

The anaesthetic should be administered only by a skilled anaesthetist, since all struggling must be prevented. For this reason, induction with non-irritating gases is desirable. Avertin is ideal for these cases, but it has to be supplemented with ether in order to get sufficient relaxation. The anaesthetist should be instructed that, in case there is any struggling, forward flexion of the head and neck must be prevented at all costs.

FIG. 2-A

FIG. 2-B

Case 37. Position of head eleven months after dislocation of the atlas on the axis. No treatment was given during this time.

When complete relaxation has been obtained, the patient is placed flat on his back with the top of his head flush with the end of the table. The operator stands at the head of the table, so that the patient's head is against his abdomen. A strip of non-elastic cloth, six inches wide, is then split longitudinally in its center for about eight inches. The patient's head is passed through this slit, so that one band of cloth comes under his occiput and one under his chin. The ends of the cloth are then tied tightly behind the operator's back. In this way a moderate amount of traction can be applied to the neck and the operator's hands still remain free. (See Figure 1.)

FIG. 2-C

Case 37. One year after manipulation. The clinical improvement was marked, although the anatomical change was very slight.

The author believes that the dangers of manipulation have been greatly exaggerated. Not only have there been no fatalities in this series in which there were ten successful manipulations, but there have been no nerve or cord complications. Fatalities occur, but so few of them have been reported that it is difficult to explain their cause accurately or to judge their frequency. In the writer's opinion, however, two main factors

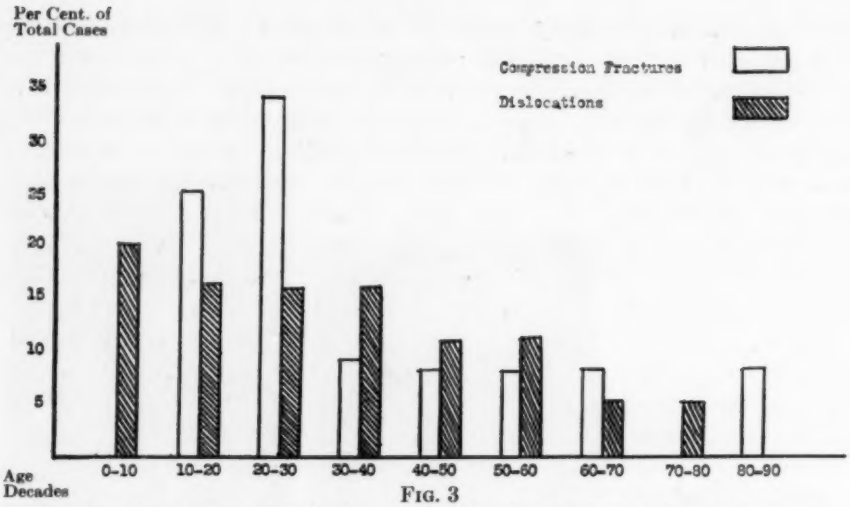

FIG. 3

Age incidence of cervical injuries. In the first decade of life, injury to the cervical spine results in dislocation rather than in fracture. After this first decade, the age incidence of the two injuries is much the same.

are responsible for these deaths. First, the operator has been unskilful and has relied upon strength rather than upon finesse. Second, fracture has accompanied the dislocation. The small fractures of the facets and the pedicles previously mentioned do not seem to be serious, but, if there is a compression fracture of the body associated with the dislocation, the operator should hesitate long before attempting manipulation. In such a case, it is better to treat the compression fracture and to allow the dislocation to go untreated. Successful healing of the fracture with a bony bridge between the injured vertebra and its neighbors will stabilize the spine so that increase in the dislocation will not occur.

The sooner reduction is attempted, the better is the chance of success. This has become almost axiomatic for other parts of the body, and the cervical spine is no exception. How long can one wait and still have a chance of being successful? In one case (Case 26) manipulation was done four months after injury with correction of approximately 50 per cent.—*i.e.*, no deformity now exists, but the patient still cannot rotate her head to the side opposite to the original deformity. One case, in which treatment was attempted ten months after injury, resulted in very little bone change, but there was about 80 per cent. improvement in deformity. Not enough old cases have been treated to answer our question, but the writer believes that, in the upper cervical spine at least, an attempt at correction should be made even after ten months if there is a permanent deformity of the head and neck. (See Figures 2-A, 2-B, and 2-C.)

After reduction has been obtained, a plaster jacket and head piece are applied in the manner already described in Part I. A complete dislocation should be held by plaster for two months, by a leather collar for two months, and, finally, by a Thomas collar for two more months. In the

case of an incomplete dislocation, plaster can be dispensed with entirely and a molded leather collar can be worn for two months, followed by a Thomas collar for one month.

After the first eight weeks, active exercises must be begun or else the muscles of the neck will become so weak that they will be unable to support the neck when freedom is finally allowed. The exercises should be of the simple postural type and should be designed to teach the patient to hold his head up and chin in in the correct mechanical position. When the leather collar is first removed for exercises, the patient should be lying down on his back without a pillow. All exercises should be done in the recumbent position for the first two or three weeks before the patient is graduated to a sitting or standing group of exercises. It is extremely

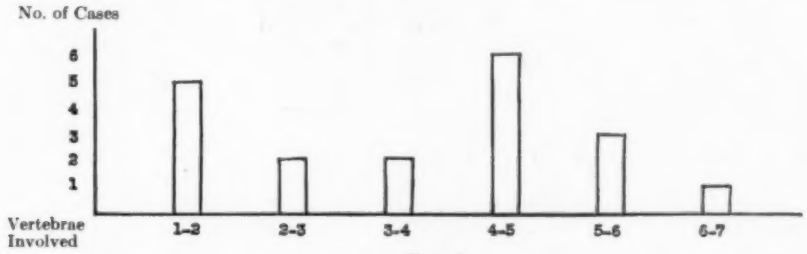

FIG. 4

Location of injury dislocations. The greatest number of dislocations occur between the first and second cervical vertebrae, where the articular facets are most horizontal and where there is no spinous-ligament attachment; also between the fourth and fifth cervical vertebrae, or at the apex of the curve when the neck is flexed.

important that the transition from complete fixation to complete freedom should be gradual and accompanied by active muscle training.

In this series, dislocations were more numerous than fractures and, in addition, they showed a more varied age incidence. (See Figure 3.) Dislocation occurred most frequently between the fourth and fifth vertebrae and next between the first and second vertebrae (Fig. 4). The younger the patient, the higher the dislocation seemed to occur. The youngest patient was seven years old, and there were three patients who were nine years of age. Two of these four patients had dislocations between the first and the second vertebrae and two between the second and third vertebrae. On the other hand, the six patients having dislocations between the fourth and fifth vertebrae ranged in age between twenty-one and seventy-four years. The average age of the patients with dislocations in the upper half of the cervical spine was twenty years as against forty-two years for those with dislocations in the lower half.

COMPLICATIONS

Early Complications

These are the complications that occur at or immediately after the time of injury and before any treatment has begun. Any severe injury

to the cervical spine, whether it be a fracture or a dislocation, may be accompanied by neurological symptoms. The most common symptoms are pain and weakness in the shoulders and in the upper extremities. These are often transient and clear up in from a few minutes to a few weeks. They are probably due to a nerve-root pressure, resulting from the general oedema that accompanies all trauma to the soft tissues. If the nerve roots are forcibly stretched, or if they are impinged upon by bone fragments, the symptoms are more severe, and there may be permanent impairment of function of the upper extremities. These complications are the result of damage received at the time of injury. They cannot be prevented, but they may be augmented by improper handling of the case.

Two of the twelve cases of fracture of the vertebral body (Cases 11 and 15) showed permanent nerve-root symptoms, and one case (Case 12) showed transient symptoms. In one case of dislocation (Case 19) there was transient nerve involvement, and two patients (Cases 20 and 21) are at present improving, although whether or not they will finally be symptomless it is not now possible to state.

More serious are the symptoms due to cord compression. This structure may be so seriously damaged that it will never recover wholly or in part. Contrary to general belief, fatal cord injury seldom accompanies a dislocation, even if the dislocation is complete. In only one of the cases with a fatal outcome in this series was there a dislocation (Case 23). The roentgenographic picture of a dislocation is much more alarming as a rule than that of a fracture. Nevertheless, the latter is much more serious. Because only one dislocation unaccompanied by a fracture was fatal, and because most of the deaths occurred following fracture without dislocation, it is the author's belief that when the two injuries (fracture and dislocation) occur together with a fatal outcome it is the fracture element that is responsible for death. Occasionally hemorrhage into the cord (hematomyelia) will give localized symptoms which are permanent (Case 10). The duration of cord symptoms cannot be determined at once, except in very serious injuries, and even with complete cord block or severance the duration of life cannot be predicted. The treatment of these cases of early cord injuries will be discussed later when the operative treatment is considered. When cord symptoms are present, however, the sooner the fracture or dislocation is reduced, the better are the chances of recovery.

Nine, or 75 per cent., of the fracture cases showed symptoms of cord compression. In five of these cases (Cases 7, 9, 13, 17, and 18) the cord damage was permanent. Three patients (Cases 11, 12, and 14) had cord symptoms which completely cleared up, and one patient (Case 10) improved but never got entirely well. The cases of dislocation were less serious as far as cord damage was concerned; only two patients (Cases 23 and 24), or 10.5 per cent., had permanent injury. Two cases of dislocation (Cases 26 and 28) showed evidence of transient cord involvement. The difference between fractures and dislocations is again seen when we com-

pare the number of nerve complications, both root and cord, accompanying each type of injury. In each of the twelve cases of compression fracture there was some sort of nerve-tissue involvement. Out of nineteen cases of dislocation there were nerve symptoms in only seven.

Late Complications

Distinct from the immediate symptoms of nerve-tissue injury are those that sometimes appear after the initial effects of injury have disappeared or even after recovery is apparently complete. These may be either of the nerve-root or of the cord type. They may not appear for some time after injury. Their occurrence is due to the gradual increase of scar tissue or of bone callus. In order to guard against them, all unnecessary irritation of tissues must be prevented. This is the main reason for the prolonged fixation used in these types of injury. If fixation is removed too early, there is a strain upon the injured parts that have not fully healed, and, in an attempt to prevent further strain, nature overdoes in her repair work. The untreated or unrecognized cases offer the best examples of late complications.

One patient in this series (Case 20) had no nerve symptoms until four

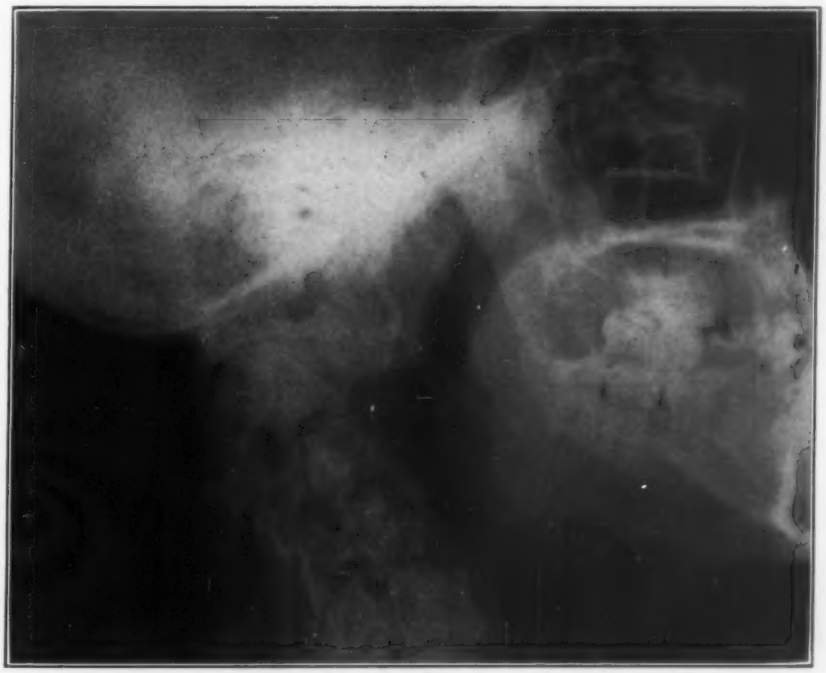

FIG. 5

Complete dislocation of the atlas on the axis, showing how extreme a dislocation may be without resulting in death or even in injury to the cord. The odontoid is fractured and carried forward, allowing the cord to curve around and to enter the foramen magnum uninjured. This illustration also shows the type of injury in which, if untreated, scar tissue may form and cause late cord symptoms. In this instance, they appeared after three months.

days after injury when he began to notice numbness and weakness of his left arm. This man had had no treatment following injury and his delayed symptoms were undoubtedly due to the weight of his unsupported head which added insult to an already injured area. Case 33 was the best example of delayed symptoms. Four months after an untreated dislocation, the patient, who had returned to work, began to have cord symptoms. These started as tinglings in his fingers and progressed so that in two weeks he was unable to walk. A similar case is that shown in Figure 5. This man had only local symptoms at the time of injury, but three months later he began to have weakness of his arms followed by spasticity of his legs.*

Redislocations occasionally occur. Sometimes the fault lies with the patient who removes the plaster without the surgeon's consent or knowledge; sometimes it is the surgeon's fault when he removes fixative apparatus too early. In either case the reason is the same,—the cervical spine has not been protected long enough. Such a complication should not occur if fixation is adequate. One patient (Case 21) was taken to the x-ray room on the seventh day after dislocation because roentgenograms taken with the portable machine were not satisfactory, and additional injury at a lower level was suspected. In spite of precautions, the dislocation partially recurred. Fortunately, there were no untoward events and reduction was again obtained by head traction, but this shows how easily redislocations may occur during the early stages of convalescence. In another case (Case 27) reduction was satisfactorily obtained by manipulation and three weeks later there was a partial recurrence while a plaster jacket and head piece were being applied. A third patient (Case 20) had a recurrence of deformity after eight weeks of head traction. This man, however, did not have a dislocation, but a fracture of the lamina with a slipping forward of the upper vertebra, simulating a dislocation.

OPERATIVE TREATMENT

In this series of cases operation has been performed for three reasons: (1) to attempt a reduction of the injury when closed methods have failed (Cases 20 and 23); (2) to stabilize a spine in order to prevent a feared recurrence of the deformity (Cases 24 and 27); and (3) to relieve the spinal cord from pressure (Cases 18 and 33).

1. It is very rarely necessary to perform an open operation. If an accurate diagnosis of the type of injury is made, the closed methods of treatment described will suffice. The two operations performed in this series were because of this "if". In both cases, an erroneous diagnosis was made. In one case (Case 23) the dislocation was bilateral, but was diagnosed as unilateral. It is possible that, even if a correct diagnosis had been made at first, operation still would have been necessary because

* This case is not included in any of the statistics since it was not treated here and the roentgenogram is used through the courtesy of Dr. Harlan Wilson, of Columbus, Ohio, who first saw the case when cord symptoms appeared and who incidentally relieved them.

for some reason, not clear, the order of reduction had to be right side and then left side, and, if a closed reduction had been attempted in the reverse order, it would have failed. What actually happened was that, because dislocation was believed to have occurred only on the left, reduction was attempted only on that side, with resultant failure. The other case (Case 20) was the one in which a disagnosis of bilateral dislocation was made when actually there was a dislocation on one side only and a fractured lamina on the other. At operation it was found impossible to hold the fracture in a reduced position. With greater accuracy of diagnosis, therefore, this type of operation should be unnecessary.

2. Two operations were performed because of fear of recurring deformity. Probably both of these were unnecessary. They were done on early cases in this series and before definite principles of treatment had been formulated. The fact that in no case has there been a recurrence of deformity following adequate fixation shows that stabilization operations are very rarely, if ever, needed. The exception to this rule is the case of congenital absence of the odontoid (Case 30) which surely needed stabilization. Another type of case that probably would require operative fixation is an ununited odontoid which has permitted an atlanto-axial dislocation. In stabilizing such cases, it has been the author's practice to lash the spinous processes (or the posterior arch of the atlas) together with fascia lata.

Sometimes the trauma of dislocation injures the intervertebral disc so that this structure gradually collapses, allowing the upper vertebra to settle down on top of the lower. Roentgenographically, this may simulate a partial redislocation (Case 34), but it should not be considered as such, since it is the result of the original trauma and is in no way the fault of treatment.

3. If the first two types of operations are seldom used, the third type is unfortunately more common. The indications for this operation (laminectomy) can best be described by considering a typical case of cord compression. A patient enters the hospital with a story of injury to his neck and the roentgenogram shows a compression fracture. There is complete paralysis below the level of injury. The immediate question is: Has the cord been compressed momentarily at the time of injury, and is this pressure now released, or is the cord still being constricted? In the former case laminectomy will do little good, but in the latter it may help. If lumbar puncture does not show a block, then the cord is probably not being seriously impinged upon. If a complete block is present, the cord is still being pressed upon by the bony deformity, or else it is so oedematous that it fills the neural canal. In either case, pressure must be relieved. The most logical way to relieve pressure is to reduce the deformity. This should be done and should be followed by another lumbar puncture. If block no longer exists, operation is not needed (Case 13). If block is still present, laminectomy must be done. The question may arise: Why not do an immediate laminectomy and reduce the deformity at the time of

operation? The answer is that laminectomy in this region, in the face of complete cord block, is a serious operation with a high mortality (100 per cent. in this series of cases, and without any evidence of relief of cord symptoms before death). Of what use, then, is operation? The answer is that it is conceivable that the cord can be temporarily injured and that, if the cause of injury be removed promptly enough, there will still be some power of regeneration left in the nerve tissues. The fact that this has never occurred in this series of cases does not rule it out.

Cord symptoms that arise as a late complication are more likely to benefit from laminectomy than the early symptoms. These come on gradually due to excess scar and callus formation (Fig. 5). The cord does not undergo a sudden, severe injury, but is gradually encroached upon. If the impinging forces can be removed reasonably early, the chances for recovery are good. Late cord symptoms do not come on as a rule for several months, at which time the patient has recovered from the shock of the initial injury and is in good condition for operation. In the only case of this sort operated upon in this series (Case 33), the results were most striking. The patient entered the hospital unable to stand; after recovery from laminectomy, he walked out and returned to his former occupation.

MORTALITY

There was only one death attributable to dislocation alone (Case 23). Another was due to post-manipulation pneumonia (Case 29). As has been mentioned before, most deaths were in cases of fracture alone (Cases 9, 17 and 18) or in cases of combined fracture and dislocation (Cases 7 and 24), in which the latter element was of minor importance. The spinal canal, therefore, is large enough and the cord is adaptable enough to permit a complete dislocation without cord pressure (Case 33 and Fig. 5). In cases of dislocation, the cord, although curving out of its normal course, still runs in a canal of normal size and smoothness. In cases of fracture, however, the compressing force of the injury constricts the spinal canal and this the cord cannot stand. If not actually severed, it becomes oedematous and the oedema in a narrowed canal causes further pressure. In all of the cases in this series death has followed such an injury. The patients have died within a week (Cases 7, 17, 18, and 23) or they have remained completely paralyzed, dying later from respiratory or kidney infections (Case 24).

FIG. 6-A

Case 19. Dislocation of the fourth cervical vertebra on the fifth. Tracing from roentgenogram taken July 15, 1932.

The mortality for the whole series was seven out of thirty-seven cases, or 19 per cent. Of the patients with

FIG. 6-B

Case 19. July 22, 1932. After manipulation.

compression fractures, 42 per cent. died; two of these patients had slight dislocations also, which probably played no part in the picture. Death occurred in 12 per cent. of the cases of dislocation. One of the dislocation deaths was due to post-manipulative pneumonia, which leaves a mortality of 6 per cent. actually due to the injury itself.

CASE REPORTS *

CASE 19. M. B., female, aged fifty.

July 1932: As the result of an automobile accident, the patient sustained a dislocation of the fourth cervical vertebra on the fifth. Weakness and sensory changes in the right arm resulted. Treatment consisted of manipulation and immobilization in plaster for one month, followed by a leather collar for four months.

December 1934: Clinical and roentgenographic examinations showed the arm to be normal, with good motion and no symptoms.

CASE 20. M. D. C., male, twenty-eight years of age.

December 1934: Due to an automobile accident, the patient suffered dislocation of the fourth cervical vertebra on the fifth and a fracture of the lamina of the fifth vertebra. Four days later, weakness and numbness of the left arm developed. A diagnosis of bilateral dislocation was made. Treatment consisted of manipulation, and reduction was obtained on the right side, but not on the left. Traction was applied for twelve days, without change. At operation the dislocation on the right side was found to have been reduced. There was no dislocation on the left side, but a fracture of the lamina of the fifth vertebra was revealed, which could not be reduced. Traction was applied for ten weeks, followed by a leather collar.

March 1935: The patient was still wearing the collar. The arm was much improved.

This case shows the necessity for accurate roentgenographic diagnosis before treatment.

FIG. 7-A

Case 20. December 1, 1934. Dislocation of the fourth cervical vertebra on the fifth and fracture of the lamina of the fifth cervical vertebra.

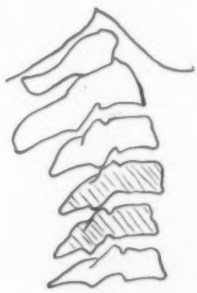

FIG. 7-B

Case 20. December 11, 1934. Partial reduction only by manipulation.

CASE 21. H. E., male, thirty-one years old.

August 1934: As the result of an automobile accident, the patient sustained a dislocation of the fifth cervical vertebra on the sixth with fracture. The right arm was paralyzed for five minutes and there was numbness of the legs for ten minutes. Neurological examination revealed a diminution of the reflexes in

FIG. 7-C

Case 20. December 21, 1934. After open reduction.

FIG. 7-D

Case 20. February 25, 1935. Partial recurrence three months after injury.

* The first eighteen cases were reported in Part I of this paper, which dealt with fractures.[4]

FIG. 8-A

FIG. 8-B

Case 21. August 11, 1934. Dislocation of the fifth cervical vertebra on the sixth, with fracture.

FIG. 8-C

Case 21. August 13, 1934. Initial reduction.

FIG. 8-D

Case 21. August 18, 1934. Partial recurrence.

the arms and impairment of sensation. Treatment consisted of the application of traction. Roentgenographic examination showed reduction. A week later the patient was taken to the x-ray room and the dislocation recurred. Traction was again applied and reduction was obtained. Traction was maintained for a period of six weeks, followed by a leather collar for four months.

February 1935: There were no neck symptoms, but a slight weakness of the right arm was present, which was improving.

FIG. 8-E

Case 21. December 18, 1934. Final reduction four months after injury.

Fixation should not be removed too early or dislocation will recur. It recurred in this case in spite of the fact that the doctor in charge watched the patient all the time when he was taken to the x-ray room.

CASE 22. D. T., female, nine years of age.

February 1931: While coasting, the patient sustained a dislocation of the first cervical vertebra on the second. Traction was applied for three days, without change. Manipulation was then done, followed by immobilization in plaster for two months. A leather collar was then worn for two months, after which a Thomas collar was worn for an additional two months.

October 1932: Motions were normal and there were no symptoms. Roentgenographic examination was negative.

FIG. 9-A

Case 22. February 11, 1931. Dislocation of the first cervical vertebra on the second.

FIG. 9-B

Case 22. February 17, 1931. After manipulation.

Dislocation without fracture is common in this region, but rare lower down in the cervical spine.

CASE 23. L. F., male, aged twenty.

November 1934: While playing football, the patient suffered a dislocation of the fifth

FIG. 10-A

Case 23. November 3, 1934. Dislocation of the fifth cervical vertebra on the sixth.

FIG. 10-B

Case 23. November 3, 1934. After manipulation had failed.

FIG. 10-C

Case 23. November 7, 1934. After open reduction.

cervical vertebra on the sixth. Complete paralysis followed. Lumbar puncture was negative. A diagnosis of dislocation on the right side was made. Treatment consisted of manipulation, which failed. Operation revealed bilateral dislocation. It was necessary to reduce the dislocation on the left side before that of the right side. The patient died six days later.

This was the only fatal case of dislocation without fracture.

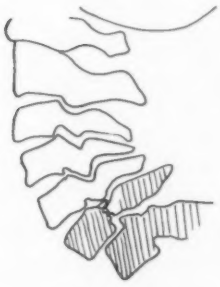

FIG. 11-A

Case 24. October 21, 1927. Dislocation of the sixth cervical vertebra on the seventh, with fracture.

CASE 24. C. H., male, fifty-two years of age.

October 1927: The patient fell thirty-five feet, sustaining a dislocation of the sixth cervical vertebra on the seventh with fracture. Complete paralysis developed on the left side and partial paralysis on the right. The patient was kept in bed for two and one-half weeks without treatment. Manipulation at the end of this time brought about some improvement. At operation, the spinous processes were lashed with fascia.

April 1928: The patient died. There was never any change in cord symptoms.

It is the author's belief that the cord symptoms were due to the fracture and not to the dislocation. An operation was performed because of fear of recurrence of the dislocation. Adequate fixation alone would have sufficed.

CASE 25. J. H., male, aged seventy-four.

April 1931: While showing his grandchildren how to stand on their heads, the patient suffered a dislocation of the

FIG. 11-B

Case 24. December 25, 1927. After manipulation and stabilization operation.

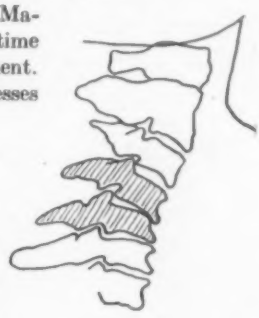

FIG. 12

Case 25. December 5, 1931. Dislocation of the fourth cervical vertebra on the fifth, eight months after injury.

FIG. 13-A

Case 26. November 8, 1930. Dislocation of the first cervical vertebra on the second, four months after injury.

fourth cervical vertebra on the fifth. There was transient pain down both shoulders. The patient was kept in bed for one month, but was given no other treatment.

December 1931: The patient entered the hospital because of a stiff neck. Neurological examination was negative. Treatment consisted of exercises and physiotherapy.

June 1932: The patient's neck was limber. Occasional pain was relieved when the patient lay down.

One should not stand on one's head at seventy-four!

FIG. 13-B

Case 26. March 11, 1931. Three months after manipulation.

FIG. 13-C

Case 26. November 8, 1930. Position of head four months after injury.

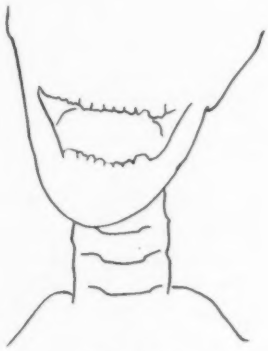

FIG. 13-D

Case 26. March 11, 1931. Position of head three months after manipulation.

CASE 26. D. J., female, twenty-nine years old.

July 1930: The patient dove in shallow water, sustaining a dislocation of the first cervical vertebra on the second. Transient paralysis of all extremities followed. The patient was kept in bed for five weeks.

November 1930: On admission to the hospital, the patient's head was turned toward the left and tilted toward the right. This could not be corrected. After manipulation, there was clinical improvement. The patient was immobilized in plaster for two months. A leather collar was then worn for one month, followed by a Thomas collar for one month.

April 1931: The chin was within half an inch of the mid-line and there was no visible deformity.

FIG. 14-A

Case 27. October 20, 1926. Dislocation of the third cervical vertebra on the fourth.

FIG. 14-B

Case 27. November 5, 1926. After manipulation.

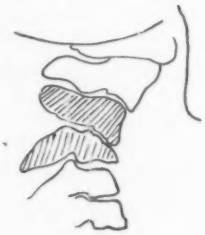

FIG. 14-C

Case 27. January 20, 1928. Fifteen months after injury. Partial recurrence, due to loss of bony substance of the fourth vertebra.

FIG. 15-A

Case 28. July 30, 1932. Dislocation of the fourth cervical vertebra on the fifth.

Some improvement is possible even after four months.

CASE 27. J. J., male, fifteen years of age.

October 1926: The patient was caught in some machinery and suffered a dislocation of the third cervical vertebra on the fourth. Manipulation resulted in good correction. Traction was applied for three weeks, followed by immobilization in plaster. There was partial recurrence. At operation, the spinous processes were lashed with fascia. The position of the vertebrae remained unchanged. Immobilization in plaster for three months followed.

January 1928: There were no symptoms and roentgenographic examination revealed no change.

FIG. 15-B

Case 28. August 3, 1932. After manipulation.

In this case, adequate initial fixation would have made operation unnecessary. The type of operation is good.

CASE 28. E. L., male, aged sixty-five.

July 1932: The patient was tossed by a bull and sustained a dislocation of the fourth cervical vertebra on the fifth. There was transient paralysis of the arms.

August 1932: On admission to the hospital, no evidence of cord damage could be observed. Treatment consisted of manipulation, followed by immobilization in plaster for two months. The plaster was removed by the patient at the end of this period.

October 1933: The patient never returned after discharge. A letter received at this time stated: "Neck O. K. Cannot come in. Am working in woods."

In this case the fixation was inadequate. Roentgenographic examination now would probably show some slight slumping forward of the upper vertebra.

FIG. 16-A

Case 29. December 14, 1932. Dislocation of the fourth cervical vertebra on the fifth.

CASE 29. J. M., male, forty-five years old.

December 14, 1932: While drunk, the patient was thrown downstairs by his landlady and lay out in the snow all night. Roentgenographic examination disclosed a dislocation of the fourth cervical vertebra on the fifth. Neurological examination was negative. Traction was applied for two days, without change. Following successful manipulation, the patient was immobilized in plaster, which was removed after three days because pneumonia had developed.

December 22, 1932: The patient died.

FIG. 16-B

Case 29. December 16, 1932. Failure of traction.

FIG. 16-C

Case 29. December 18, 1932. After manipulation.

In this case of severe dislocation without cord involvement,

death was due to anaesthesia on top of exposure to cold and wet. Manipulation should have been delayed.

CASE 30. O. N., male, twenty years of age.

September 1931: While "bridging" in a gymnasium, the patient sustained a dislocation of the first cervical vertebra on the second, causing sudden pain in the neck. The clinical diagnosis was: "Forward dislocation on left". The roentgenographic

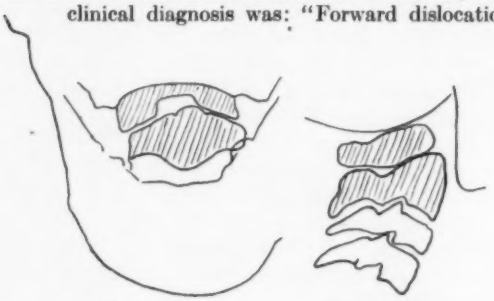

FIG. 17-A

Case 30. September 3, 1931. Dislocation of the first cervical vertebra on the second.

FIG. 17-B

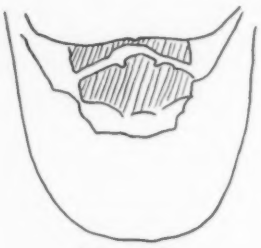

FIG. 17-C

Case 30. September 20, 1931. After traction.

diagnosis was: "Backward dislocation on right; congenital absence of odontoid". Treatment consisted of traction with complete reduction, followed by a leather collar for three months.

October 1932: There were no symptoms and motion was normal. Operation was refused.

This case shows what might happen to an ununited odontoid. The patient should have had a stabilization operation.

CASE 31. T. P., female, nine years old.

November 1932: While skipping rope, the patient turned her head suddenly and suffered a dislocation of the second cervical vertebra on the third. Manipulation was done, followed by immobilization in plaster for two months and a Thomas collar for an additional two months.

November 1933: There were no symptoms and motion was normal.

Palpation of the posterior nasopharynx through the mouth showed an abnormal relationship which otherwise could not be felt.

CASE 32. G. P., female, nine years of age.

January 1932: The patient fell off a sofa and sustained a dislocation of the second cervical vertebra on the third. Treatment consisted of head traction, followed by a brace for six weeks. The patient could not afford a leather collar. At the end of this period, a Thomas collar was worn for two weeks.

January 1933: There were no symptoms and motion was normal.

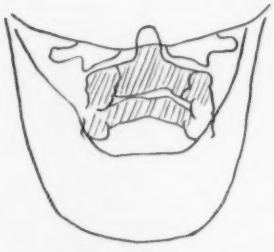

FIG. 18-A

Case 31. November 4, 1932. Dislocation of the second cervical vertebra on the third.

This was a border-line case. If the question: Is it dislocated? arises, the only way to find out is to treat the case and see if there is

FIG. 18-B

Case 31. November 9, 1932. Note rotation of axis without forward displacement.

improvement. If traction makes no change, then there is probably no dislocation.

CASE 33. W. S., male, aged fifty-three.

November 1931: The patient fell down a flight of stairs and sustained a dislocation of the first cervical vertebra on the second, and fracture of the odontoid. He remained at home for three weeks and then returned to work.

March 4, 1932: The patient experienced a prickling sensation in his fingers.

March 12, 1932: A week later he was unable to button his clothes.

March 14, 1932: He complained of numbness of the feet.

March 16, 1932: The patient began to stagger and stopped working.

March 18, 1932: He was unable to walk and was admitted to the hospital. Examination disclosed weakness and atrophy of the hands and arms. All reflexes were hyperactive. Treatment consisted of laminectomy. At operation, it was found that the cord made an S turn at the site of injury and was bound down by adhesions.

July 1932: The patient's arms and legs were nearly normal. He walked well and could button his clothes.

This was a severe case without cord symptoms for three months. The symptoms were due to the formation of scar tissue and not to bone impingement. This case was ideal for operation and is typical of late cord complication.

CASE 34. A. V., male, forty years of age.

April 1929: The patient was thrown off a wagon and sustained a dislocation of the fifth cervical vertebra on the sixth. He was kept in a local hospital for ten days.

April 1930: The patient entered the hospital complaining of pain in the neck. Treatment consisted of a Thomas collar for sixteen weeks and physiotherapy.

January 1931: The patient still complained of pain. Motion was normal.

June 1931: Pain was still present, but the patient was back at work.

January 1932: Because of the persisting pain, the patient had stopped work. Neurological and medical consultations resulted in a diagnosis of compensation neurosis.

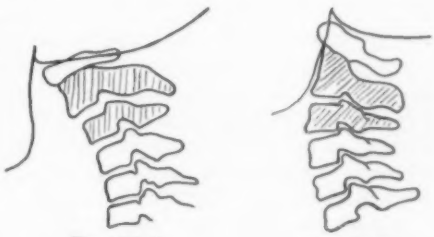

FIG. 19-A FIG. 19-B

Fig. 19-A: Case 32. January 14, 1932. Dislocation of the second cervical vertebra on the third.

Fig. 19-B: Case 32. January 18, 1933.

Early adequate treatment might have saved all this trouble.

CASE 35. E. W., male, aged thirty-three.

May 1930: The patient fell off a truck and suffered a dislocation of the third cervical vertebra on the fourth, and fracture of the odontoid. For three days, he experienced difficulty in swallowing.

June 1930: The patient entered the hospital. Treatment consisted of a leather collar for three months, followed by a Thomas collar for one month. Manipulation was not done because of the fracture of the odontoid and a fracture of the lateral mass of the third cervical vertebra.

January 1931: The patient was back at work. Motion was normal, but he stated that there was some discomfort

FIG. 20

Case 33. March 18, 1932. Dislocation of the first cervical vertebra on the second, and fracture of the odontoid. Roentgenogram four months after injury.

FIG. 21

Case 34. November 27, 1931. Dislocation of the fifth cervical vertebra on the sixth. Roentgenogram two years and seven months after injury, showing loss of intervertebral disc.

FIG. 22-A

FIG. 22-B

Case 35. June 12, 1930. Dislocation of the third cervical vertebra on the fourth, and fracture of the odontoid, one month after injury.

if he kept his head bent down very long. There had been no recurrence of the dislocation, and the odontoid had united.

Adequate fixation resulted in union of the odontoid. Manipulation in the presence of fractures should be done cautiously, if at all.

FIG. 22-C

Case 35. January 9, 1931. Seven months after injury.

CASE 36. C. W., male, twenty-one years old.

April 1930: The patient fell off a roof and sustained a dislocation of the fourth cervical vertebra on the fifth. Treatment consisted of manipulation, immobilization in plaster for three months, and a leather collar for two months. During the period of immobilization, weakness and atrophy of the left shoulder were discovered. The question then arose: Was this present before?

September 1930: Motion was normal. Atrophy and weakness had disappeared.

November 1930: There were no symptoms.

Neurological examination should always be done at once, so that it may be referred to later if nerve complications arise. It was neglected in this case.

CASE 37. H. W., female, seven years of age.

FIG. 23-A

Case 36. April 25, 1930. Dislocation of the fourth cervical vertebra on the fifth.

FIG. 23-B

Case 36. August 23, 1930. Four months after manipulation. Loss of intervertebral disc.

June 1933: The patient underwent a double mastoid operation. The head was in the torticollis position when the patient came out of the anaesthesia. Preoperative roentgenograms were said to have showed a normal spine. Postoperative roentgenograms showed a dislocation of the first cervical vertebra on the second.

April 1934: The patient entered Hospital X and the following report was made: "Hands off. Manipulation would be fatal."

May 1934: The patient was admitted to the Massachusetts General Hospital. Treatment consisted of manipulation, resulting in clinical correction without any demonstrable change in the roentgenogram. The patient was immobilized in plaster for two months

and a leather collar was worn for two months, followed by a Thomas collar for an additional two months.

April 1935: Some asymmetry of the neck and limitation of motion were observed, but there were no symptoms.

FIG. 24-A FIG. 24-B

Case 37. May 23, 1934. Dislocation of the first cervical vertebra on the second, eleven months after injury.

The opinion of Hospital X, one of the best-known hospitals in the country, is typical of the general feeling about these injuries. However, even after eleven months, clinical improvement can be attained.

CONCLUSIONS

1. Fractures and dislocations of the cervical spine should be reduced at once, just as are similar injuries elsewhere in the body.
2. Fractures are more serious than dislocations, and are more liable to be fatal or to be accompanied by irreparable cord or nerve damage.
3. Dislocations are very rarely fatal. Their reduction is not dangerous. They will not recur if properly treated.
4. Fixation after reduction either of a fracture or of a dislocation must be complete and of long duration.
5. Early complications cannot be avoided. Proper treatment begun early will lessen their permanent effects.
6. Late complications are usually due to lack of early treatment and to inadequate fixation.
7. Operation is rarely indicated except to relieve late cord symptoms.

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NAVICULAR-CUNEIFORM ARTHRODESIS FOR FLAT-FOOT

An End-Result Study

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In 1931 Hoke described navicular-cuneiform arthrodesis as an operation which he had used since 1923 in the treatment of extremely relaxed flat feet. As the result of personal communications with Hoke, the operation had been done at the New York Orthopaedic Dispensary and Hospital upon nine patients previous to 1931, the earliest in 1927, and, following Hoke's favorable report, it has been carried out more frequently. By the end of 1934, seventy-two patients had had navicular-cuneiform arthrodeses for flat feet. The purpose of this article is to present primarily an end-result study of these seventy-two patients and a brief discussion of the actions of the long muscles of the foot.

The factors concerned in the maintenance of the normal longitudinal and transverse arches of the foot are the shapes of the bones of the foot, the strong ligaments which bind them together and limit their motions, and the properly balanced and synchronized actions of the long muscles. Abnormalities in any one of these factors, particularly in a growing foot, will produce abnormalities of the arch. The first two will not be discussed, and conceptions as to the relative importance of some of the last may vary.

The long muscles of the foot have been carefully studied by many observers and their actions and relative and actual power estimated and calculated. All will probably agree that a strong or contracted gastrocnemius has a detrimental effect upon the longitudinal arch, that a weak or paralyzed gastrocnemius will produce a cavus foot of the calcaneus type, and that the tibialis posterior, the peroneus longus, and the flexor hallucis longus are the principal arch-elevating muscles. These muscles, acting synergistically, supply powerful opposition to the arch-depressing action of the gastrocnemius, particularly as the heel is raised and weight is transferred to the forefoot in walking.

Many may not agree with the following conception of the action of the tibialis anterior. The author believes that it has no arch-elevating or supporting value for the following reasons:

1. It inverts or supinates the forefoot on the rearfoot, producing one of the elements of flat-foot.

2. It elevates the first metatarsal head and the anterior limb of the medial longitudinal arch, directly opposing the action of the peroneus longus, and produces a lowering of the medial longitudinal arch.

3. In walking, it contracts only during the swing phase of the step and for the instant of heel weight-bearing as the advanced foot is put to

the ground and the forefoot is lowered. When three-point weight-bearing is reached, and as weight moves forward to the forefoot, putting the greatest strain on the arch, the tibialis anterior is relaxed.

4. When it acts against a contracted gastrocnemius, or attempts to dorsiflex the foot against superimposed body weight, it throws a strain on the longitudinal arch.

Further, since each of the actions of the tibialis anterior produces one of the elements of flat-foot, the writer believes that weakness or paralysis of this muscle alone, particularly in a growing foot, is an important factor in the production of an exaggerated arch or claw-foot, the mirror-image of flat-foot.

Navicular-cuneiform arthrodesis, usually combined with a lengthening of the Achilles tendon, is a worth-while surgical procedure in the treatment of properly selected cases of flat-foot. The benefit derived from the operation is only the correction by arthrodesis of an existing sag or relaxation at the navicular-cuneiform joint, plus the temporary removal of the arch-depressing action of the calf by lengthening of the Achilles tendon.

This study of seventy-two patients upon whom the operation was performed prior to 1935 has shown that it has definite limitations and that it is not a cure-all for relaxed flat feet.

Each of the seventy-two patients, except six, had both feet operated upon, making a total of 138 feet operated upon. There were twenty-nine males and forty-three females, ranging in age from seven to thirty-three years. The average age at the time of operation was fourteen years, and we believe the early adolescent years from ten to fifteen to be the ideal time for the operation.

The preoperative complaint was of deformity (flat-foot) only in thirteen patients, deformity and fatigue in thirteen, and deformity with pain and fatigue in forty-six. Preoperative conservative treatment had been used in some instances for as long as ten years.

Some degree of contracture of the gastrocnemius was present in sixty-five patients, the dorsiflexion of the foot being limited at from 95 to 130 degrees, and in most patients at about 100 degrees. Lengthening of the Achilles tendon was done some months previous to the navicular-cuneiform arthrodesis in two patients, at the same time as the arthrodesis in sixty-one, and three weeks following the arthrodesis in six.

The technique of the operation was essentially that described by Hoke. In many instances, however, only the medial cuneiform was included in the arthrodesis, instead of the medial and the middle cuneiforms. In the end-result examination no difference could be found attributable to this fact alone. Postoperative treatment consisted of bed rest with plaster boots for from six to eight weeks and physiotherapy and the wearing of metal arch supports for from three to six months.

Recently we have been able to see forty-six of the seventy-two patients in a special follow-up study, including clinical and roentgenographic

examinations. This represented eighty-seven of the 138 feet operated upon. Most of the remaining twenty-six patients were seen at least one year after operation, so that a study of their charts and roentgenograms was considered valuable. Since in the final analysis each group coincided very closely, they are all included in this report. Considering each foot as to cosmetic, anatomical, and functional end results, we found that there were thirty, or 21.8 per cent., with an excellent result; forty, or 29 per cent., with a good result; and thirty-four, or 24.6 per cent., with a fair result; and the same number with a poor result. In other words, there were approximately 50 per cent. with satisfactory results and 50 per cent. in which the outcome left much to be desired,—in one-half of the latter, the results were definitely poor.

The thirteen patients (twenty-three feet operated upon) who before operation had complained of flat feet without symptoms showed at the last examination three feet anatomically excellent, nine good, seven fair, and four poor. All of these patients continued symptom-free except one who had occasional pain in the longitudinal arch, and two who had pain over the Achilles tendon. In one of the latter cases the tendon had pulled out at the site of the lengthening, resulting in a calcaneus deformity. This was the only patient in the entire series in whom such an event occurred, and she had had a previous lengthening of the tendon many years earlier.

The thirteen patients (twenty-six feet operated upon) who had complained of flat feet with fatigue showed two feet anatomically excellent, five good, ten fair, and nine poor. Nine patients no longer had fatigue; two continued to have fatigue; and two complained of fatigue and moderate pain at the site of the arthrodesis.

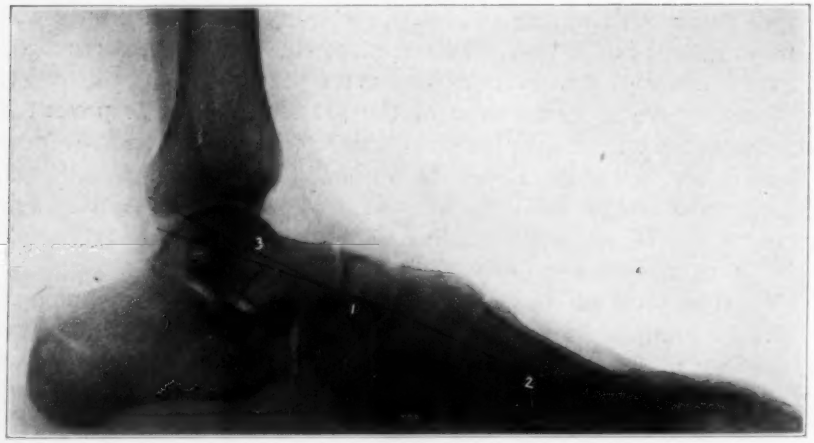

FIG. 1

Normal lateral standing view of left foot. Line *1* is drawn through the center of the navicular perpendicular to its articular surfaces; *2* is drawn parallel to the long axis of the first metatarsal; and *3* is drawn parallel to the long axis of the neck of the talus.

FIG. 2-A

J. G., aged thirteen years, an ideal case. Preoperative roentgenogram of the left foot, taken on April 27, 1934, showing no sag at the talonavicular joint and a sag of 15 degrees at the navicular-cuneiform joint.

FIG. 2-B

J. G. Roentgenogram of the left foot, taken on January 6, 1936, one year and eight months after operation. The arch is much improved; a slight navicular-cuneiform sag persists; fusion is solid.

The forty-six patients (eighty-nine feet operated upon) who had complained of flat feet with pain and fatigue showed nine feet anatomically excellent, thirty-one good, twenty-eight fair, and twenty-one poor. Twenty-six patients no longer had either pain or fatigue; twelve still had fatigue but no pain; and eight still had pain in the longitudinal arches, in two of which the pain was worse than before operation.

Six patients had navicular-cuneiform arthrodesis at one operation, followed in three weeks by a second operation for lengthening the Achilles tendon. The end results in these patients showed four excellent feet,

FIG. 3-A

W. S., aged ten years, a case of a plantar-flexed talus. Preoperative roentgenogram of the right foot, taken on April 7, 1934, showing a marked sag (27 degrees) at the talonavicular joint. There is no sag at the navicular-cuneiform joint. Lengthening of the Achilles tendon was done on April 12, 1934, followed by a navicular-cuneiform arthrodesis on November 4, 1934.

FIG. 3-B

W. S. Roentgenogram of the right foot, taken on December 28, 1935, thirteen months after arthrodesis, showing flat-foot and a sag at the talonavicular joint.

four good feet, two fair, and two poor. The patients in this group with a poor result had plantar flexion of each talus, a condition we now consider a contra-indication to navicular-cuneiform arthrodesis. Where feasible, we now prefer to perform the arthrodesis at one operation and the tendon-lengthening at a second operation three weeks later, for, in order to obtain adequate correction at the navicular-cuneiform joint, the first metatarsal head must be well depressed or plantar-flexed. This will not be accomplished if any upward pressure is made on the forefoot in attempting to bring the foot to 90 degrees of dorsiflexion, the position desired after

lengthening the Achilles tendon. Even careful use of the Hoke molded-sole plaster technique has not always assured that no upward pressure would be exerted on the first metatarsal head, with consequent inadequate correction at the navicular-cuneiform joint and production of a certain amount of fixed supination of the forefoot on the rearfoot.

Roentgenograms taken preoperatively, immediately after operation, and at the last examination were studied. The lateral standing view was found to be most useful, though often misleading if not a true lateral exposure, and often showed an arch better than would be expected from clinical examination. In each case measurement of the actual amount of sag at the navicular-cuneiform and at the talonavicular joints was attempted. (See Figure 1.) Preoperatively there was an average sag of 10.5 degrees at the navicular-cuneiform joint, and of 6 degrees at the talonavicular joint. At the last examination the average sag at the navicular-cuneiform joint was 0 degrees and 5 degrees at the talonavicular joint. (See Figures 2-A and 2-B.)

The appearance of the roentgenograms left reasonable doubt as to the presence of solid bony union at the site of the navicular-cuneiform arthrodesis in eighteen, or 13 per cent., of the 138 feet operated upon. In ten of these the results were poor, at least in part attributable to the failure of union; however, in eight the results were fair or better, fibrous union of sufficient strength to maintain the proper relationship of the bones probably having occurred.

We were particularly interested in the analysis of the twenty-three patients (thirty-four feet operated upon) with poor end results. We found the following factors which we believe had definite unfavorable effects upon the end results:

1. Plantar flexion of the talus (Figs. 3-A and 3-B); that is, too great relaxation and sag at the talonavicular joint.
2. Too great generalized relaxation of the foot, making arthrodesis of one joint and correction of alignment at this joint insufficient to restore a satisfactory arch.
3. Obvious deformity of one or more of the tarsal bones.
4. Inadequate correction or no correction obtained at operation, resulting in a persisting and fixed amount of supination of the forefoot on the rearfoot.
5. Failure of the operative fusion; in ten cases the results were poor, in eight they were fair or better.
6. Obesity of the patient, with excessive strain on the arches of the foot.
7. Arthritis in the tarsal joints.
8. Stretching or pulling out of the Achilles tendon (one foot).

The end result was the same in both feet in fifty-six of sixty-six patients who had both feet operated upon. Since in these patients the operation was performed by different surgeons, it would seem that the proper selection of the patient is of much greater importance than minor

differences in technique. We now consider the following conditions ideal for navicular-cuneiform arthrodesis:

1. The patient should be in the early adolescent years of life, and should not be obese.

2. The foot should not be severely relaxed or severely pronated, as arthrodesis of one joint in this type of foot is insufficient to restore a good arch.

3. The lateral roentgenogram, with the patient in the standing position, should show a definite sag or relaxation at the navicular-cuneiform joint, and only a slight sag, if any, at the talonavicular joint.

4. There should be no definite deformity in any of the tarsal bones.

5. There should be no arthritis in the foot or the ankle.

6. If the navicular tubercle is large, or if an os tibiale externum is present, it should be removed, as this greatly improves the cosmetic result and possibly also the functional result by slightly altering the pull of the tibialis posterior.

SUMMARY

Of 138 cases of flat-foot, treated by navicular-cuneiform arthrodesis during the years 1927 to 1934 inclusive, the end results were excellent in thirty, good in forty, fair in thirty-four, and poor in thirty-four.

From this study it would seem that, in carefully selected cases of flat-foot, navicular-cuneiform arthrodesis is a worth-while surgical procedure.

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MYOSITIS OSSIFICANS PROGRESSIVA

With Report of a Case

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The literature on myositis ossificans has recently been reviewed by Mair. Recent papers on the differential diagnosis [4, 9], on therapeutic methods [6, 10, 11], on pathogenesis and histogenesis [1, 12], and on the roentgenographic findings [3] may also be consulted. The nature of the disease remains obscure, and the therapy disappointing.

Recent clarification of the state of calcium in the blood [8] has added interest to the study of abnormalities of calcification and ossification. On the other hand, the finding of these authors that, in certain diseases associated with gross abnormalities in the skeletal system, of which from the data here presented myositis ossificans appears to be one, the calcium in the blood is neither qualitatively nor quantitatively changed from the normal apparently makes it necessary to search further for the pathological physiology of this disease.

Following the lead of Guyatt, Kay, and Branion, who employed beryllium carbonate to induce rickets in rats, one of the authors, at the suggestion of Dr. F. C. McLean, attempted similar procedures in a human subject in a case of this disease. No record has been found so far in the literature that this chemical has ever before been employed on a human.

CASE REPORT

Personal History

The patient is a white female, twenty-three years old, weighing eighty-six pounds. No untoward complications were noted during the mother's pregnancy, and no instruments were used at delivery. The birth weight was seven pounds, and the infant was breast fed. The patient had the usual childhood diseases. Two brothers had no physical or mental defects. One brother had drooling from the mouth and a slight impediment in speech. He died at the age of nine; the cause of his death was not known. The only abnormality noted during the patient's infancy and early childhood was the inability to move the great toes of both feet.

When five years of age, the patient fell from a height of four feet and the cervical spine was severely injured. She was unable to turn her head after this injury, and later the right elbow became stiff. Ankylosis of many joints developed between the ages of six and nine years. At the age of twelve years she sustained a fracture in the distal end of the right radius and was admitted to St. Andrew's Hospital, Murphysboro, Illinois. A roentgenographic examination of the torso was made, which showed extensive ossifications in the musculature and in other extraskeletal tissues. At the age of sixteen the patient fell from a fire escape and was unconscious for three days. No fractures were noted. At the age of eighteen the patient was in a railway accident. The exact injury sustained is unknown, but she was unconscious for ten hours. She has spent the past twelve years of her life in charitable institutions. Her crippled condition caused her to

be dependent on nursing care and on one occasion, when a ward of a county farm, she took roach powder with suicidal intent.

The patient was admitted to the Anna State Hospital for the mentally ill, at Anna, Illinois, on January 17, 1934. No psychotic behavior was noted during her entire period of hospitalization.

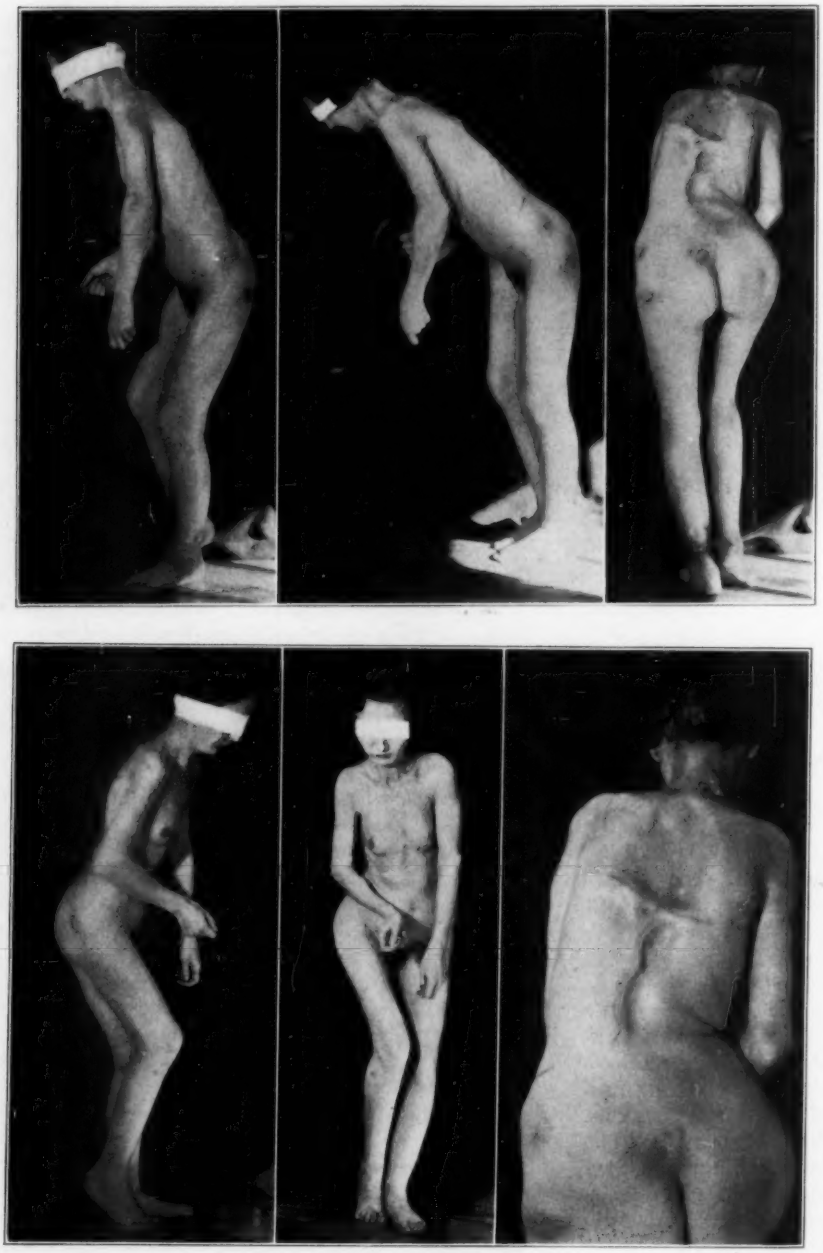

FIG. 1

Family History

This was essentially negative. Her father met with an accidental death, and her mother died of an unknown cause during the climacteric period. There were no abnormalities in either parent.

Physical Examination

The patient was four feet, ten inches tall in a position of flexion. She could not stand erect. (See Figure 1.) She was ill-nourished, markedly deformed, and unable to flex her hips so that she could sit. The mucous membranes and conjunctivae were pale. She was unable to open her mouth. There was a hard palpable mass in the thyroid gland, two by two centimeters in size. The pupils reacted to light and to accommodation. There was a marked blowing first sound at the apex. The left chest was depressed anteriorly from the level of the seventh rib. Expansion was limited on both sides and breathing was abdominal in type. Satisfactory palpation and percussion of the lungs were not possible because of the abnormal thoracic cage. No cough or expectoration was noted. A slight elevation of temperature occurred irregularly in the afternoon. There was no evidence of pulmonary lesion. The digestive, urinary, and reproductive systems were negative. The superficial reflexes were exaggerated. Deep reflexes were diminished bilaterally. Organic reflexes were intact. There were no disturbances of taste. The sense of smell was normal. Hearing and vision were normal. Marked dermographia was noted. The outstanding abnormalities were confined to the skeletal and muscular systems, in the form of ankyloses, exostoses, distortions, and calcifications, and are represented by Figures 2, 7-A and 7-B, taken from tracings of roentgenograms.

FIG. 2

Laboratory Findings

Blood examination:

Red blood count	4,500,000 to 4,200,000
Hemoglobin (Sahli)	85 per cent. to 75 per cent.

White blood count	9,000 to 5,000
Differential count (100 counted)	
Polymorphonuclear leukocytes	66 per cent. to 56 per cent.
Lymphocytes	28 per cent.
Monocytes	5 per cent.
Basophiles	1 per cent.
Eosinophiles	3 per cent. to none
Blood platelets	150,000
Coagulation time	4 minutes
Bleeding time	5 minutes
Blood pressure	110/70

Kahn and Wassermann tests on blood were negative.

Spinal puncture was not done because of the patient's condition.

The sedimentation test showed a slight hastening in the precipitation of erythrocytes.

Urine: The volumes of the twenty-four-hour specimens taken for a period of a week averaged 1,625 cubic centimeters and were essentially negative except for one plus albumin, occasional pus cells, specific gravity of 1.026 to 1.015 with a calcium oxide value of 0.087 grams, and 1.40 grams of inorganic phosphorus (phosphoric acid) for daily volume. The urine was light green, cloudy, and of putrid odor.

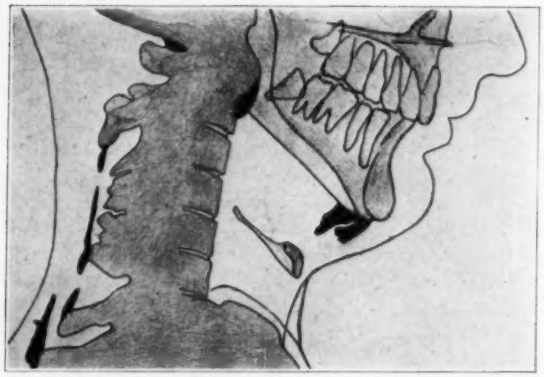

FIG. 3

Sputum: The sputum was scanty. Repeated examinations for acid-fast bacilli were negative.

The basal metabolic rate could not be obtained because of the patient's inability to open her mouth sufficiently.

Diagnosis and Differential Diagnosis

The following four diseases should be considered primarily: (1) myositis fibrosa; (2) Pott's disease; (3) multiple exostosis; (4) calcinosis universalis. The differential points of the first three from myositis ossificans progressiva are given by Mair and as a rule offer no difficulty. The differentiation from the last disease, however, is not so simple. Nevertheless, in calcinosis universalis the following six points, which were advanced by Mair, should be of value:

1. Lesions of calcinosis universalis are harder and contain a greater proportion of calcium salts than does the fully formed bone.
2. The nodules discharge chalky homogeneous debris.
3. The disease appears later in life and is more common in females.
4. Generally there are present no congenital abnormalities such as an absence of the interphalangeal joints of the great toes (Fig. 6) and microdactylia which occurs in 75 per cent. of the cases of myositis ossificans progressiva.
5. The tendons and fascia are never involved.
6. These calcium deposits apparently have the spontaneous power of reabsorption.

There are a few organs, which contain striated muscle fibers, that are never involved in the abnormal ossifications. Most significant among them may be mentioned the diaphragm, the tongue, and the sphincters.

The diagnosis of myositis ossificans progressiva was made in our case after a thorough examination of roentgenograms which extended over a period of eleven years. (See Figures 7-A and 7-B. Compare the lumbar spines and iliac crests.) The diagnosis was

further strengthened after special studies of blood serum and repeated determinations of calcium and inorganic-phosphorus content had been made.

A biopsy was performed on the muscle tissue in November 1934 in order to determine any alterations or abnormalities. The tissue was removed from the left biceps, fixed in 10-per-cent. formaldehyde solution, and studied in the pathological laboratories of Rush Medical College and the Illinois Research and Educational Hospital. Both laboratories reported that there was nothing abnormal either in the striations or in other respects. Considerable induration and only a slightly increased opacity to x-rays had developed at the site of the biopsy six weeks after it was performed.

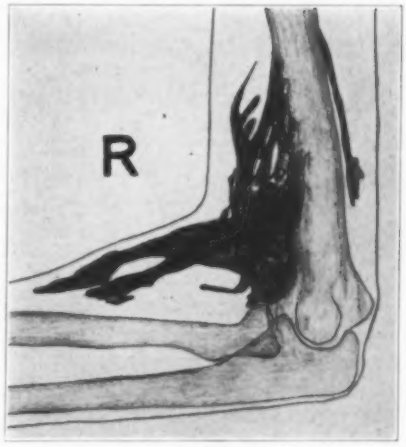

FIG. 4

In May 1935 a biopsy of abnormal growth from bone tissue was performed and specimens were sent to the same institutions in order to determine whether these growths were calcifications or ossifications. In the former case, the diagnosis of calcinosis universalis would be indicated, and, in the latter, that of myositis ossificans progressiva. This point was positively settled by the following report after a thorough microscopic study of the bone tissue: "The sections contain

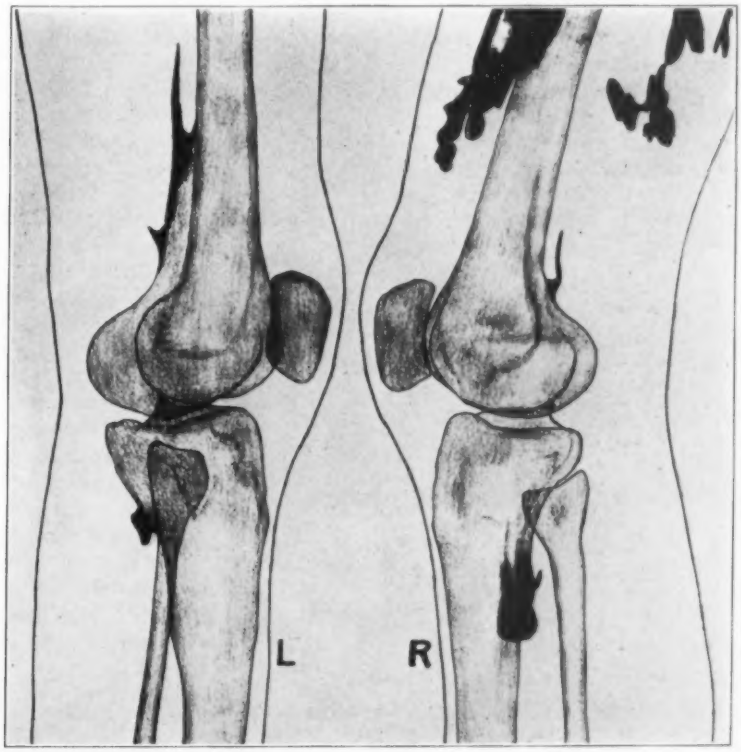

FIG. 5

atrophic striated muscle fibers, and islets of young bone. The diagnosis is myositis ossificans." This diagnosis was further confirmed at the University of Chicago Clinics. The availability of roentgenograms for study over a period of eleven years also added evidence of the presence of myositis ossificans progressiva.

Special Studies

Special features of the case were studied with the cooperation of the two laboratories mentioned. All routine chemical analyses of the blood yielded normal values. Repeated analyses of serum gave values for calcium ranging from 9.6 to 10.7 milligrams per 100 cubic centimeters, and for inorganic phosphorus from 3.4 to 4.2 milligrams per 100 cubic centimeters. Direct observation of calcium-ion concentration of the serum by the method of McLean and Hastings gave a value of 4.5 milligrams per 100 cubic centimeters, in close agreement with a value of 4.65 milligrams as calculated from total calcium and total protein. The serum was found to have a phosphatase content of 0.22 units.

All examinations of the blood having given normal results, attempts were made to modify the calcium-phosphorus relationships. For one month, alkaline sodium phosphate, twelve grams per day, as used by Brooks in the treatment of calcinosis universalis, was administered without appreciable influence either upon serum calcium or upon inorganic phosphorus. Following a rest period, beryllium carbonate, found by Guyatt, Kay, and Branion to cause a marked reduction in the inorganic phosphorus of the serum when fed to rats, was administered, first at the rate of three grams per day and later at the rate of six grams per day, a total of 200 grams being given without untoward symptoms. No appreciable change in serum calcium was observed. Serum inorganic phosphate was 2.9 milligrams per 100 cubic centimeters after two weeks and 3.4 milligrams per 100 cubic centimeters at the termination of the period of observation. The final sample of serum was tested for ability to produce calcification *in vitro* in rachitic bone slices from the rat, with negative results. There was no roentgenographic evidence of decalcification, either in the skeleton or in the abnormal deposits at this time, and the area in which a biopsy had been performed actually showed evidence of a slight deposit of calcium during the period of medication.

It was not to be expected that the administration of alkaline sodium phosphate, or of beryllium carbonate, over the relatively short periods during which they were given, would produce recognizable roentgenographic changes in the skeleton or in the abnormal bone deposits. It was hoped, however, in the case of beryllium carbonate, which apparently acts by forming an insoluble beryllium phosphate in the intestinal tract, that the inorganic phosphate in the blood could be reduced sufficiently in concentration to delay or to prevent further calcification, possibly even with some decalcification of existing lesions. There was, naturally, no *a priori* reason to believe that any such effect would act differentially upon normally and abnormally situated bone. Failure to produce any significant lowering of the inorganic phosphate of the serum may probably be attributed to insufficient dosage in relation to the amount of phosphate in the diet,

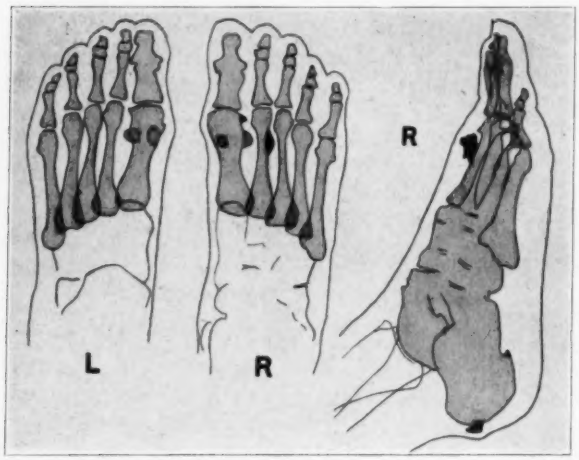

FIG. 6

but since it was impracticable to control the diet no data were secured on this point.

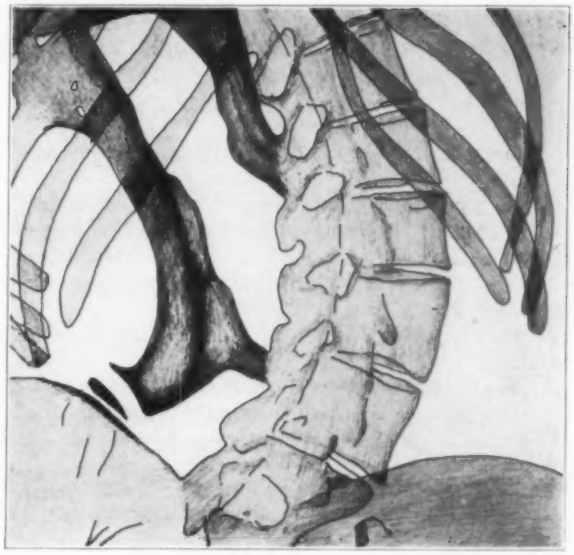

FIG. 7-A
1924

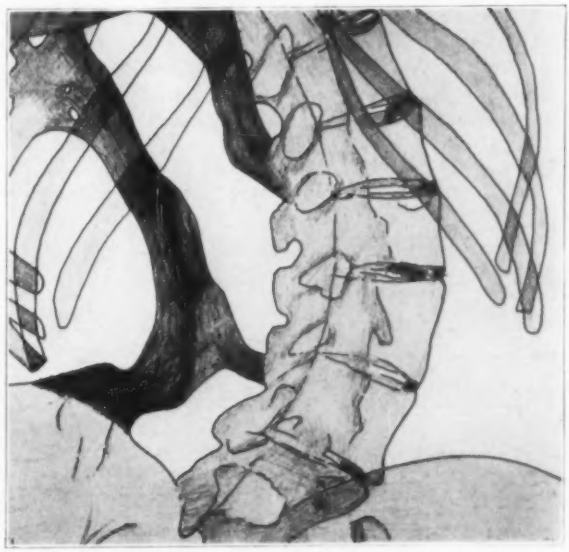

FIG. 7-B
1935

This case is of interest for the following reasons:

1. There are extensive pathological changes throughout the skeletal and muscular systems of the body, not excluding the lower extremities. It is also interesting to note that the usual span of life which is from ten to fifteen years does not hold good here, although the exact age of onset could not be determined from the history. It is, however, indisputable that there was a congenital absence of interphalangeal joints in each great toe (Fig. 6).

2. The availability of records, including roentgenograms, over a period of more than a decade, which clearly demonstrate the chronological progression of the disease in the musculature, is of immense help.

3. There have been extensive chemical studies in an attempt to throw some light on the pathological physiology of the disease, with uniformly negative results.

4. This is apparently the first case in which beryllium carbonate has been used on a human subject. The results are at present disappointing. The authors are hopeful, however, that favorable results may be obtained in human beings if the subjects are available prior to the full development

of the osseous system, at a period comparable to the stage in which this chemical was effective in producing osteomalacia in young rats.

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EXTRA-ARTICULAR ARTHRODESIS OF THE SHOULDER

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From the Children's Hospital, Detroit

One would hesitate to report two cases of extra-articular fixation of the shoulder joint for tuberculosis in children were it not for the comparative infrequency of this lesion. Whitman states that tuberculosis of the shoulder joint occurs in not more than 2 per cent. of all cases of joint tuberculosis and that it is more frequent in adults than in children. In the majority of the cases the primary disease is in the head of the humerus. It rarely originates in the scapula and only occasionally does it appear to be primarily synovial.

In the October 1933 issue of *The Journal of Bone and Joint Surgery*, R. Watson Jones described an operative procedure to obtain extra-articular arthrodesis of the shoulder joint. He reported two cases of such arthrodesis in adults and one other case combining an extra-articular and an intra-articular arthrodesis. At the time this article appeared we had one case of tuberculosis of the shoulder joint in a child, which required operation. The joint was operated upon and fused according to the extra-articular method described by Jones. In a short time ankylosis in a good functional position of abduction was obtained and the result was very satisfactory. Since that time we have had one other case of tuberculosis of the shoulder joint in a child. This joint was operated upon by the same method with an equally good result. It is now three years since the first operation and two years since the second operation.

FIG. 1

Case 1. Before operation.

FIG. 2

Case 1. After operation.

FIG. 3

Case 2. Before operation.

FIG. 4

Case 2. After operation.

The technique of the operation as described by R. Watson Jones will not be reviewed, but our two cases follow.

CASE REPORTS

CASE 1. S. S., a male, aged eleven years, first entered the Clinic in 1931, due to a deformity of the spine which clinically and roentgenographically had the appearance of tuberculosis involving the ninth, tenth, and eleventh thoracic vertebrae. The patient was treated on a Bradford frame in a sanatorium for over two years and then, wearing a back brace, was up and about. In 1933 he reentered the Clinic, due to a stiff shoulder which was in the adducted position and had the appearance of tuberculosis.

In October 1933 an extra-articular arthrodesis was done according to the technique of R. Watson Jones. The arm was held in 75 degrees of abduction in a plaster spica and later in an abduction brace for eleven months. The brace was then gradually removed. In December 1935 the shoulder was solidly ankylosed in this position of abduction. The child is now able to get his hand on the top of his head easily and the scapula allows the arm to drop to the side.

It is interesting to note that this patient has had a flare-up of the spinal lesion which was treated without operation and which will now require a fusion operation of the spine.

CASE 2. M. M., a female, aged ten years, was first examined in 1935 with a history of having been unable, for twelve months prior to admission, to raise her hand to her head and of increasing stiffness. The arm was held close to the side and there was marked limitation of motion. Clinically and roentgenographically the lesion had the appearance of tuberculosis.

In June 1935 an extra-articular arthrodesis was done according to the technique of R. Watson Jones. The arm was held in 70 degrees of abduction in a plaster spica for three months and then a steel abduction splint was applied and gradually removed. The shoulder is solidly ankylosed in this position of abduction; no pain is present, and the patient is able to place her hand on the top of her head. The roentgenograms show bony union.

CONCLUSIONS

A study of the two cases of tuberculosis of the shoulder joint in children, treated by the Jones extra-articular arthrodesis, yields the following conclusions:

1. The operation is well adapted for fusing a tuberculous shoulder in a child and gives firm bony ankylosis with little reaction on the part of the patient.
2. Bony fusion is speedily accomplished.
3. The operation should be done when the process is quiescent.
4. The cosmetic and functional results following the operation are good.
5. The epiphyses of the bones involved are not destroyed by the operation.
6. To date there has been no recurrence of the symptoms in the two shoulders operated upon by this method.

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A COMPLETE COMPOUND SUBASTRAGALAR DISLOCATION OF THE TARSAL BONES

BY DUNLAP P. PENHALLOW, M.D., F.A.C.S., WASHINGTON, D. C.

The following case of a complete compound dislocation of the tarsal bones from the astragalus is believed to be of sufficient rarity to justify its being reported, especially as there were no associated fractures.

E. P., a white male, aged twenty-five, an ironworker, was injured on May 9, 1935. He stated that, while working on a ladder, he had been struck by an iron bar which had, knocked him off of the ladder. He had landed on his right ankle, and had turned it. He was immediately taken to the hospital where he was seen by the author shortly after admission.

Examination showed the patient to be a rather large and well-developed young white male. He did not appear to be in any great pain, and there was no shock. General physical examination was essentially negative. Examination of the right ankle showed a lacerated wound, four inches in length, extending horizontally just below the external malleolus. The foot was in pronounced inversion which was so marked that the plantar aspect was rotated over 90 degrees. The articular surfaces of the astragalus were completely exposed, due to the marked rotation of the foot. The scaphoid and the other anterior tarsal bones and the metatarsals were completely displaced from the astragaloscaphoid articulation, while the os calcis was dislocated from the astragalocalcaneal articulation. (See Figures 1-A, 1-B, and 2.) Circulation of the foot was good and the dorsalispedis artery could be felt pulsating.

FIG. 1-A

Dislocation of the os calcis and of the anterior tarsal bones from the astragalus. (See also Fig. 1-B.)

The patient was taken to the operating room very shortly after admission, and, under general anaesthesia, the wound was thoroughly cleansed and irrigated. All devitalized and unduly torn tissues were excised and the dislocation was reduced with very little difficulty. No attempt was made to suture the ligaments, as these were rather badly torn. The external wound was closed rather loosely with interrupted sutures and without drainage. A large dressing was used and a cast was applied from the toes to the tibial tubercle with the foot slightly everted. Roentgenograms (Figs. 3-A, 3-B, and 3-C), taken after the operation, showed a complete reduction of the dislocations.

FIG. 1-B

FIG. 2

Lateral roentgenogram, showing a complete subastragalar dislocation of all of the tarsal bones.

Following the operation, the patient presented an uneventful convalescence. There was no elevation of temperature and at no time was there any evidence of infection. The patient was discharged from the hospital on May 20, 1935. The cast was continued for a little over four weeks following his discharge from the hospital, after which time he was furnished with a support and was allowed to bear some weight on the foot, but he was still using crutches. Physiotherapy was given three times a week and the patient was

gradually allowed to bear more weight on the foot. He finally returned to work in the early part of August. At the time of his return to work he walked without any limp. Dorsiflexion and plantar flexion were essentially normal as compared with the left ankle.

FIG. 3-A

FIG. 3-B

FIG. 3-C

Roentgenograms after reduction.

Active inversion of the foot was essentially normal, but there was slight restriction on active eversion. The wound was well healed, and there appeared to be practically no functional disability.

This case is presented simply as a case of a complete dislocation of the tarsal bones from the astragalus without any associated fractures, but complicated by an extensive, open, traumatic exposure of the articulating surfaces of the astragalus.

AN UNUSUAL FRACTURE-DISLOCATION OF THE TARSAL SCAPHOID WITH DISLOCATION OF THE CUBOID

BY DUNLAP P. PENHALLOW, M.D., F.A.C.S., WASHINGTON, D. C.

While it is true that fractures of the tarsal scaphoid do occasionally occur, and dislocations of single tarsal bones take place rather rarely, the author feels that the following case, which presents a combination of a fracture and a dislocation of the same bone, together with a partial dislocation of the cuboid bone, may be of interest.

J. S., a white male, aged thirty-four, a laborer, was injured on August 30, 1933. He stated that the rope which he was using to hoist some timber caught and knocked him off of the scaffold on which he was standing. He managed to keep hold of the rope and slid to the ground, a distance of seventy-five feet, striking with considerable force on both

FIG. 1-A

Fracture of the scaphoid and upward displacement of the upper fragment, also partial dislocation of the cuboid. (See Fig. 1-B.)

FIG. 1-B

Anteroposterior view, before reduction.

FIG. 2-A

Anteroposterior view. After reduction.

FIG. 2-B

After reduction, showing practically complete reposition of the fracture and of the dislocation of the scaphoid and of the cuboid. (See Fig. 1-A.)

feet. He was not rendered unconscious, but sustained multiple injuries for which he was taken to the hospital, where he was seen shortly after the accident.

On admission he was conscious and rational, but extremely nervous. Examination of the head was essentially negative, except for some superficial abrasions on the forehead and cheeks. The left elbow and both wrists and hands presented some superficial abrasions. Extensive abrasions were noted on the mesial aspect of the upper half of the left thigh, as well as over the inner aspect of the leg. There were numerous contused areas over the shoulders and back. With the exception of the right foot, which presented a marked deformity at the mediotarsal joint, there were no evidences of fracture. There was a marked pes cavus and the forefoot was inverted. Pronounced tenderness was present over the mediotarsal joint, and all motions of the foot were extremely painful. There was some thickening on the dorsal surface about the mediotarsal joint, but no crepitus could be elicited. The left foot was tender to palpation, but there was no deformity, and no signs of fracture or dislocation could be observed.

Roentgenograms of the left foot were negative. The right foot showed a partial dislocation of the tarsal scaphoid, associated with a fracture through the inferior and mesial portions of the bone with some separation of the fragments. There was also a partial dislocation of the cuboid. (See Figures 1-A and 1-B.)

The right foot was immobilized in a temporary splint, and on the following day, under general anaesthesia, the foot was manipulated. The dislocation could not be reduced by manipulation alone; reduction was finally accomplished by a combination of manipulation and the use of a heavy mallet, after the method of Cotton for fractures of the os calcis. This combination of methods appeared to be successful, as the deformity of the foot was corrected and the contour appeared to be essentially the same as in the left foot. Plaster was applied from the toes to the tibial tubercle, and the foot portion was molded well into the arch. Roentgenograms (Figs. 2-A and 2-B), taken immediately following the manipulation, showed good reduction of the fracture and also good reposition of the dislocation both of the scaphoid and of the cuboid.

The cast was continued for about four weeks, after which physiotherapy was started and the cast was continued for about three weeks more. The patient was then fitted with an arch support and was allowed to bear weight gradually on the foot. Convalescence was uneventful and the patient finally returned to work in March 1934. At that time he showed no deformity of the foot. There was very slight thickening about the mediotarsal joint, but the joint was flexible. Motions of the ankle were normal. There was neither swelling of the foot nor pain. The patient was fitted with a leather and felt arch support which he was instructed to use for a few weeks. At the time of his return to work there did not appear to be any functional disability. He was seen again after having been at work for a month. He showed no disability and had been able to carry on well with his work.

The interesting fact about this case is that this man slid and fell a distance of seventy-five feet and sustained only minor injuries, except for the fracture-dislocation of the tarsal scaphoid and the partial dislocation of the cuboid.

BENNETT'S FRACTURE OF THE THUMB

BY SIR WILLIAM I. DEC. WHEELER, LONDON, ENGLAND

Some years ago the author contributed a paper on the subject of Bennett's fracture of the thumb, from the point of view of a surgeon who had sustained this injury. Signs, symptoms, prognosis, and treatment were reviewed in detail. It is the purpose of this communication to record the end result approximately five and a half years after the injury.

The writer sustained a Bennett's fracture of the left thumb in July 1931, and it was then realized that permanent incapacity to carry on his profession might follow.

The fracture was reduced and held in the extended and abducted position by means of plaster-of-Paris in which a wire "gallows" was incorporated. About a fortnight later, when the writer was attempting to land a large fish with a small rod, the fragment slipped, and "the deformity was again obvious. . . . The thumb felt as if it could never again control a pair of scissors, as if the tying of a ligature would never be possible, and that the application of even the lightest forceps to a vessel was out of the question. Attempts to oppose the thumb to the other digits were fruitless, the only possible opposition was to the side of the first finger." No further attempt at reduction was made. It was ascertained by means of the fluoroscope that movements were not blocked by the fragment.

Occupational treatment consisted in the frequent immersion of the hand in a basin of hot water, at the bottom of which lay artery forceps, scissors, and ligatures. Daily attempts (very feeble at first) were made to open and to close the forceps, to tie ligatures,

FIG. 1

FIG. 2

Recent x-rays showing the amount of voluntary abduction and adduction. Firm bony union is present and there is some shortening, but no arthritic changes.

and to handle the scissors. Massage followed these immersions, and in the intervals the thumb was supported by a firmly applied adhesive elastic bandage. With this support and two pairs of rubber gloves, it was possible to undertake minor surgical operations after seven weeks' treatment. Pain and awkwardness persisted for about six months. After twelve months all disability had disappeared, and after five and a half years the thumb is perfect from a functional point of view. All the fingers can be opposed to the thumb with full force; there is no pain and no sign of arthritic change. The prominence of the subluxation in the "snuff-box" remains, and there is slight shortening. With the exception of a very slight limitation of abduction, movements are free and normal.

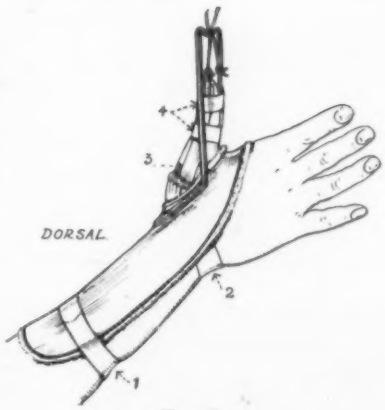

FIG. 3

Splint designed by the author for Bennett's fracture of the thumb. (*Courtesy of The Medical Press and Circular.*)

1: Strapping to fix splint to forearm;
2: Strapping under splint to keep pressure pad in position;
3: Portion of pressure pad protruding through opening in splint;
4: Longitudinal and circular extension straps.

It is well known that in some cases of this fracture the most perfect reduction may be followed by poor function and that the reverse is also true,—*i. e.*, excellent function may follow a poor reduction. Treatment by fixation and extension in plaster-of-Paris is suitable when the patient is within easy reach of facilities for the renewal of the splint should this become necessary. By whomever applied, plaster may fail in its purpose, and a reapplication becomes necessary. Under many familiar conditions plaster-of-Paris is best avoided in the treatment of this fracture and of many other common fractures.

As a result of his own experience, and with the knowledge that the splint recommended by Bennett was inefficient, the writer designed the splint shown in Figure 3.

This splint is a padded aluminum gutter with a large aperture at one end. From this opening a wire gallows projects in the position of an abducted thumb. An adhesive felt pad is placed over the site of the fracture, and the splint is applied to the lateral aspect of the forearm with the thumb projecting through the aperture. The fracture is reduced by manipulation and extension. The latter is maintained by tapes secured to the thumb by adhesive and tied tightly to the end of the gallows.

If the patient faithfully keeps the tapes taut, and if the splint is firmly bandaged in position or secured by plaster for about three weeks, the result is quite satisfactory. As a rule, fixation in a light plaster for an additional three weeks is desirable.

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CONSERVATIVE METHOD OF CORRECTING FLEXION DEFORMITY OF THE KNEE COMPLICATED BY POSTERIOR LUXATION OF THE TIBIA

BY M. THOMAS HORWITZ, M.D., PHILADELPHIA, PENNSYLVANIA

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From his successful employment of Haggart's method of skeletal traction for correcting flexion deformity of the knee complicated by posterior luxation of the tibia, the writer, combining these principles with those of the Quengel method as outlined by Mommsen, has devised the following non-operative procedure, which is applicable in this type of case where operation might be contra-indicated or perhaps refused.

FIG. 1

Turnbuckle *A* controls posterior luxation; turnbuckle *B* corrects the flexion deformity. The direction of either force is controlled through the perforated bar.

A plaster-of-Paris spica is applied from the costal cage to the involved knee, preferably with a V-shaped tongue covering and protecting the patella. A separate plaster bandage is applied from below the knee to the toes with the foot at right angles. Padding must be well applied at the sites of maximum pressure,—the anterior surface of the lower thigh and the patella, the posterior surface of the upper portion of the leg, and behind the heel and the tendo achillis.

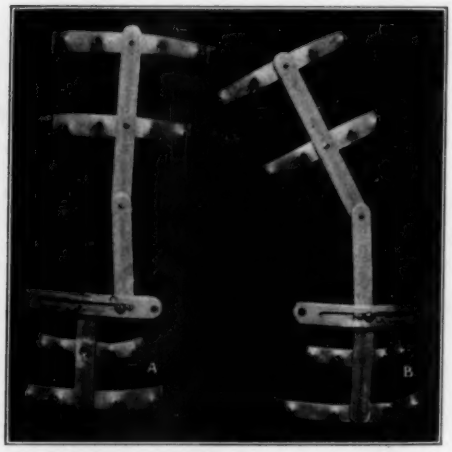

FIG. 2

Hinge with sliding device incorporated in the lower segment. Note position of the sliding bar prior to (hinge *A*) and during (hinge *B*) control of the posterior displacement of the upper portion of the tibia. The screws are tightened to maintain each correction.

A perforated bar is incorporated into the thigh portion of the plaster spica and turnbuckles *A* and *B*, of varying sizes, are attached to the leg. (See Figure 1.) When, by means of turn-

*Service of Harry Finkelstein, M.D.

FIG. 3

Showing the entire apparatus assembled. Turnbuckle *A* has been detached and the sliding hinge fixed to allow correction of the flexion deformity through turnbuckle *B*.

buckle *A*, the posterior displacement is completely corrected, as noted by control roentgenograms, the lateral hinges are incorporated with their axes in the line of the femoral epicondyles. Turnbuckle *A* is removed and correction of the flexion is carried out through turnbuckle *B* (Figs. 2 and 3).

The slot constructed at the lower end of the hinge allows repeated control of the recurring posterior luxation by reinserting turnbuckle *A*, without altering the position of the axis of the hinge.

This apparatus was of striking value in treating a six-year-old male child with a severe 90-degree flexion deformity of the right knee, the site of proved tuberculous infection. The debilitative condition and youth of the patient contra-indicated operative intervention. Numerous types of hinges, of elastic traction and turnbuckles, and of plaster-of-Paris bandages were employed, each resulting in a persistently recurrent and severe posterior displacement of the tibia. The method of treatment described was instituted with complete correction of both deformities in one month and with a minimum of discomfort to the patient. Careful clinical and laboratory observations failed to disclose any disturbance, either local or general, of the disease process.

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A FLEXIBLE NEEDLE ("FLEXO-NEEDLE")

Its Use in the Nicola Operation for Recurrent Dislocation of the Shoulder *

BY A. M. RECHTMAN, M.D., F.A.C.S., PHILADELPHIA, PENNSYLVANIA

From the Orthopaedic Service of the Jewish Hospital of Philadelphia

While the Nicola procedure is the most favored form of operation in the treatment of recurrent dislocation of the humeral head, much effort is required, involving considerable loss of time, in threading the tendon of the long head of the biceps through the drill hole (or canal) in the upper end of the humerus. Inasmuch as this is due to the lack of an efficient guiding instrument, a flexible needle, fitted with a heavy linen guide suture, has been devised, which has served to shorten the time and to improve the technique of this operation.

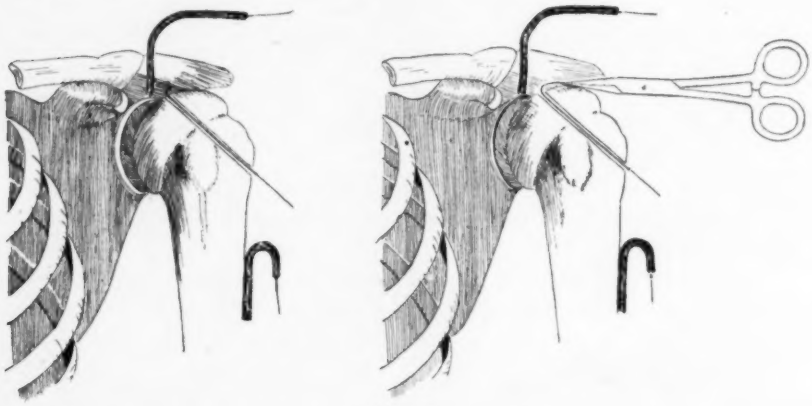

FIG. 1

Diagrammatic representation of the shoulder girdle, showing the cut biceps tendon, drilled canal in the upper end of the humerus, flexible needle in the canal, and the hemostat withdrawing the needle from the joint.

The patients who require this operation are frequently muscular, making the operative wounds deep. To facilitate threading the tendon in its new course from above downward through the drill hole, Nicola suggests stripping the clavicular origin of the deltoid muscle. However, with the aid of the flexible needle, this is not necessary.

With the use of this needle, in following the Nicola procedure, a shorter incision may be made. The muscles are separated, the tendon of the long head of the biceps is freed and divided, and a canal is drilled into the upper end of the humerus (as suggested by Nicola). The capsule is opened and a long suture is fastened to the cut end of the proximal portion

* Presented at the joint meeting of the Philadelphia Orthopaedic Club and the Orthopaedic Section of the New York Academy of Medicine, Philadelphia, Pennsylvania, November 20, 1936.

of the biceps tendon. The flexible needle, with its attached guide suture, is then passed from below upward through the drilled humeral canal. (See Figure 1.) The needle is grasped with a hemostat and, because of its flexibility, it can easily be drawn from the drilled canal and through the incision made in the capsule. Of course, the distal end of the suture is not drawn through the drill hole.

The flexo-needle is removed, and the guide suture is tied to the suture attached to the tendon and then pulled through the bony canal. Formerly this was often the most time-consuming part of the operation, whereas, with the flexible needle and the guide suture, all this may be accomplished in a few moments.

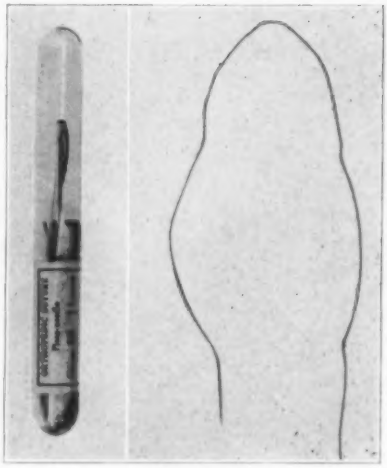

FIG. 2

Flexible needle with swedged-on linen thread. Needle sealed in tube. Shape of needle distorted to suggest its flexibility.

The flexo-needle is made of untempered steel which permits of any degree of flexibility. The needle is three inches long and has a diameter of twenty-six thousandths of an inch. (See Figure 2.) The needle is the swedged-on type and the guide suture is a black linen thread, twenty-eight inches in length and tested to twenty pounds of tension, so that it is about twice the strength of silk. The needle and thread are packed in individual glass tubes containing alcohol. The suture is sterile and it may be boiled.

The needle, although flexible, has sufficient rigidity, when straight, for firm handling and use. The needle may be cut to any required length and bent into any desired shape to facilitate its passage through and around bones. The end of the needle is sharp, so that it may be used to suture tendons and other soft tissues. It was devised, however, to carry a heavy guide suture. When the end of the needle is grasped with a hemostat as it emerges from a drill hole in a bone, the needle is sufficiently flexible to bend readily about the bone and it may be removed with practically no added injury to the bone or to its cartilaginous covering.

In addition to its use in the Nicola operation, the flexible needle has also proved a valuable aid in facilitating other operative procedures. With its assistance, a Gigli saw may be passed around a bone with comparative ease, tendons may be more easily passed through drill holes in bones and tendons, and fascia and muscles may be anchored deeply into cavities at the base of trap doors made in bones. The needle and its attached guide suture facilitate the placing of fixative kangaroo or wire sutures through and around bones.

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WIRE FIXATION OF THE SMITH-PETERSEN NAIL

BY VERNON L. HART, M.D., MINNEAPOLIS, MINNESOTA

Several surgeons who have had considerable experience with the Smith-Petersen three-flanged nail for the internal fixation of fractures of the neck of the femur have reported that there is a tendency for the nail to slip out of the femur.

FIG. 1

Smith-Petersen nail with stainless-steel wire passed through the cannulated head. The wire ends are twisted and firmly fixed after the wire is threaded through a hole drilled through the cortex of the femur. (See Figs. 2 and 3.)

Dr. Melvin S. Henderson[2] of the Mayo Clinic recently reported the lag-screw method of internal fixation. Dr. Henderson stated: "The method was developed because in some instances the metal flanged nail became loose."

R. Watson Jones[1] of Liverpool has reported his experience: "It might be thought probable that absorption of bone round the nail due to an irritative hyperaemic decalcification would account for frequent failure. . . . That there is some decalcification is undoubted, and the remarkable tightness of the nail when it is first driven in is not maintained for more than a few weeks. After that time it is not difficult to slide the nail up and down its socket in the bone." He described the use of a stainless-steel domed cap which is screwed over the head of any nail which shows a tendency to slip out of the bone.

The writer wishes to present a simple modification of the Smith-Petersen nail which is used routinely to prevent the nail from gradually slipping and losing its relationship with the proximal or head fragment. (See Figures 1, 2, and 3.) A centrally cannulated Smith-Petersen nail, which has a relatively small oblique hole drilled into the cannulated head, is used. Following successful introduction of the nail, a piece of stainless-steel wire is passed through the cannulated head. The ends of the wire are twisted and firmly fixed after the wire is passed through a small hole drilled through the cortex of the distal fragment or shaft of the femur.

The nail should be introduced with the hole facing the greater trochanter, since the segment of the head of the nail facing the greater trochanter is not buried as deeply within the cortex of the femur after the head is driven home. (See Figure 2.)

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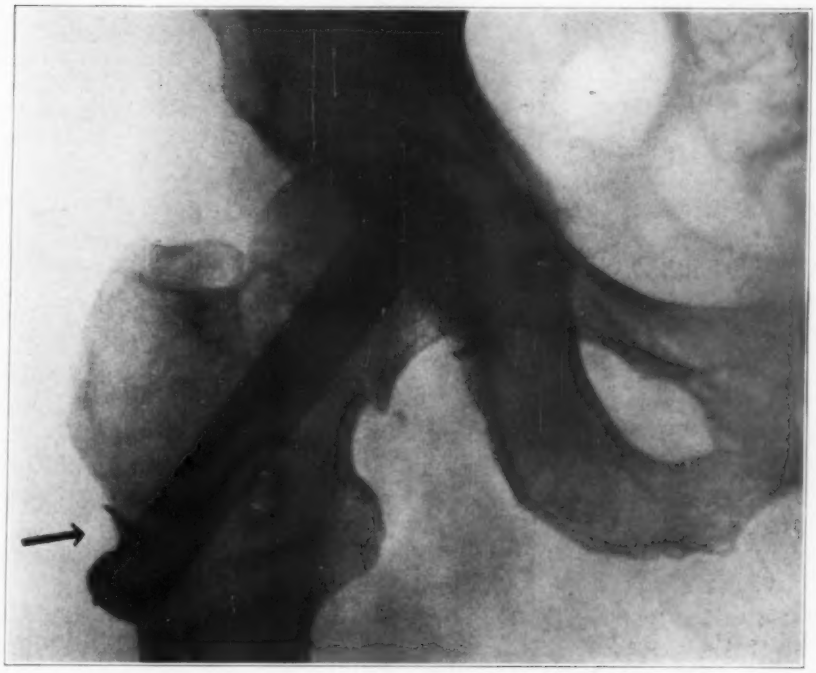

FIG. 2

Arrow points to stainless-steel wire fixation of Smith-Petersen nail.

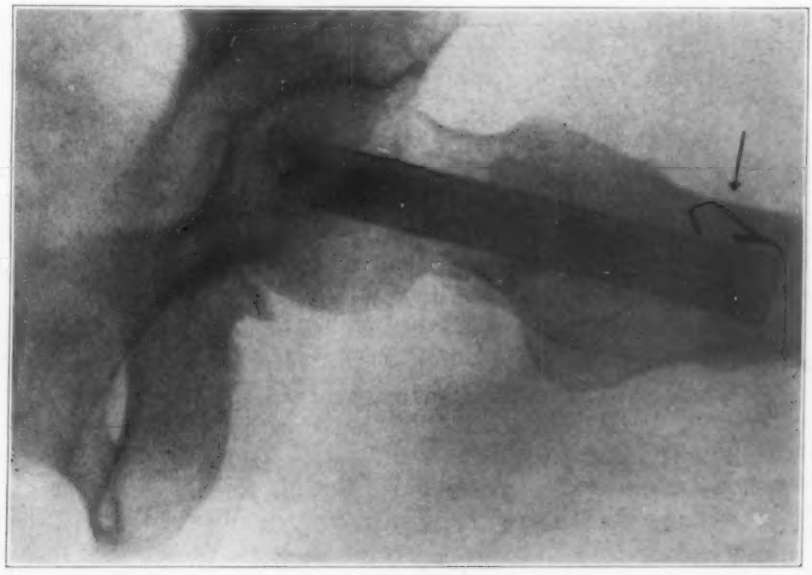

FIG. 3

Lateral view of femoral neck and Smith-Petersen nail. Arrow points to the wire fixation of the nail.

LEG HOLDER FOR OPERATIONS ON THE KNEE AND ON THE FEMUR *

BY EDGAR D. OPPENHEIMER, M.D., NEW YORK, N. Y.

In operations on the knee, the tibia is pulled away from the femur in order to separate the joint surfaces. A large object over which the flexed knee can be laid is desirable, but it must be adjustable and it must be handled so as to maintain the operative sterility. Also, in operating on the shaft of the femur, as in the case of a fracture, the tensor fasciae latae and the hamstrings must be relaxed in order to have traction on the lower fragment. It is also desirable to elevate the thigh for a more lateral exposure. In working with the knee flexed, it is easier to retract the muscles, to reduce the fragments, and to maintain effective traction. Here again, an adjustable sterile platform is needed. To meet these requirements, the author has devised a leg holder, a description of which follows.

This apparatus is made of rustless steel, weighs five pounds, and, when folded, is twenty-two inches over-all. It can be sterilized with the basins or the instruments. It consists of a platform, eight inches long, which goes under the thigh and is hinged to a ten-inch support for the leg. From each of these supports project two jointed legs which are connected by a plate, two inches square, making a parallelogram. Since the supporting rods are held at the pivotal point on a two-inch plate, the pivot is not on one point. If these rods are crossed, and if the plate is inverted, the apparatus is five inches lower and can be used for a small limb and the pivotal point remains as before. A transverse longitudinal bar with a ratchet allows locking at any degree of angulation. The operator can adjust it and remain sterile. If the apparatus is locked at 90 degrees, making a square, the foot is free from the table, and the weight of the assistant's hand upon the foot pulls the knee down and forward and pivots it over a fulcrum below. The leg is supported by the shelf and the thigh hangs down from it. Thus traction is applied on the lower femoral fragment, and the fracture is readily reduced.

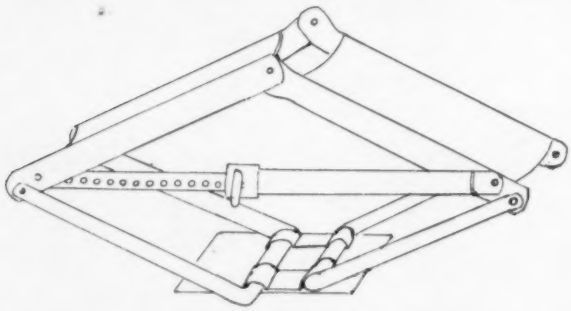

FIG. 1

The practical value of this apparatus lies in the facts that it is sterile

* The apparatus described in the two papers by Dr. Oppenheimer was exhibited at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Cleveland, Ohio, January 1937.

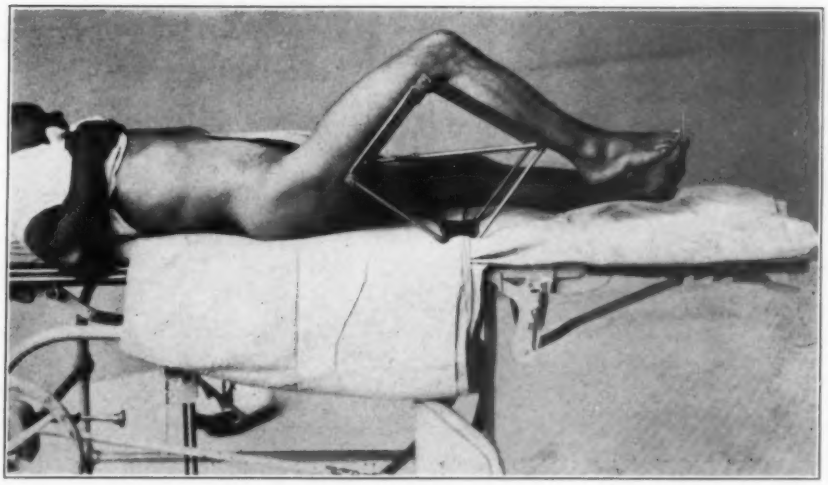

FIG. 2

and that it can be adjusted by the surgeon. An assistant would be unable to hold the limb effectively. Therefore, this leg holder simplifies the two operative manoeuvers considerably.

FRAME FOR APPLICATION OF PLASTER JACKET IN PRONE POSITION

BY EDGAR D. OPPENHEIMER, M.D., NEW YORK, N. Y.

Plaster jackets are applied with the patient either in a hanging position or in a horizontal prone position. Most of the jackets are put on for spinal injuries, lumbago, sciatic scoliosis, and conditions which make it impossible to handle a patient in the hanging position as comfortably as when he is recumbent and relaxed. Many simple frames with a stretched canvas have been improvised for this purpose. Usually hyperextension is desired, and some of the fracture tables provide for this. The author believes that the apparatus which he has devised will be helpful in that it accomplishes hyperextension, makes the work easier, and is simple and inexpensive to construct.

This apparatus has the appearance of a sled on which the patient rests face down with the knees fully flexed, as do children on their sleds. The over-all length is thirty-eight inches and the width is twenty inches. The height of the frame, when folded, is six inches. The apparatus is made of gas pipe, three-quarters of an inch in diameter; it weighs eight pounds and is portable. The end bars are raised about five inches above

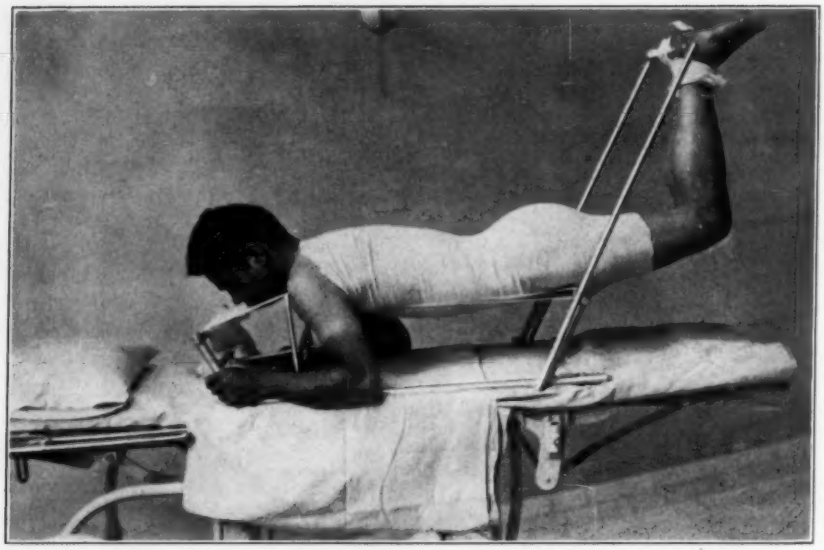

FIG. 3

the runners or side bars. There is a movable cross-bar which should rest just below the chin. Ordinary muslin, about seven inches wide, is stretched between the two end bars, and is fastened and wound on a spool or tube held by a ratchet. Tightening the ratchet prevents sagging and limits extension. The movable cross-bar at the neck is raised above the ends and, instead of being straight, is bent downward in the middle. In this way the sides of the canvas or the muslin are tighter than the middle part, which prevents flattening of the abdomen. A short longitudinal slit is cut in the muslin through which the patient puts his nose, enabling him to rest his head without forced hyperextension of the neck.

The lower bar should cross the thighs three or four inches below the anterior superior spines and the movable cross-bar is adjusted above the sternum after the patient has been placed in position. There is a second jointed hoop, about thirty-six inches long and hinged at the lower end, which can be folded flat when not in use. After the patient has been placed prone on the sled this hoop is elevated and the feet are fastened to it by a double sling around the ankles. The height to which the feet are raised controls the hyperextension, relieves the pressure of the lower bar against the thighs, and prevents the patient from rolling off sidewise. If the legs are drawn to one side, lateral bending is obtained. After the jacket has been applied, the foot holder is dropped, the patient is rolled over on his back, and the muslin is cut off.

This frame differs from others in that: (1) the lateral bars are depressed to be out of the way in plaster application; (2) the sling is looser in the middle than on the sides; (3) it is adjustable as to size; (4) it is adjustable as to the amount of extension; (5) it has a practical leg holder; and (6) it is portable.

MULTIPLE SESAMOIDS OF THE HANDS AND THE FEET

BY ROBERT F. PATTERSON, M.D., F.A.C.S., KNOXVILLE, TENNESSEE

In the upper extremity, sesamoid bones are found only on the palmar surface of the hand. According to Gray, two are constantly present at the metacarpophalangeal joint of the thumb; one is frequently present at the corresponding joint of the little finger, and one or two at the same joint of the index finger.

In the lower extremity, two sesamoid bones are normally present at the metatarsophalangeal joint of the great toe. Occasionally one or two are found under other toes at the corresponding joint. Dwight states that one may be found under the interphalangeal joint of the great toe in 50.6 per cent. of the cases, one at the metatarsophalangeal joint of the second toe in 1.8 per cent. of the cases, and two at the same joint of the little toe,—at the tibial side in 5.5 per cent. of the cases, and at the fibular side in 6.2 per cent. of the cases. There is a distal interphalangeal sesamoid opposite the middle of the joint of the second toe in 8 per cent. of the cases. The author can find no mention of a case in which these bones occurred in all of the toes of both feet as well as at unusual sites in the hands.

The following case is presented as an anatomical curiosity. The complete uniformity with which the bones occurred in the corresponding extremities is noteworthy.

Mrs. H. B. T., a housewife, presented herself for treatment of an old sprain of her ankle with residual tenderness in the ankle and injury to the ball of the right foot. Roentgenograms of the feet revealed the presence of multiple and uniform sesamoids. One

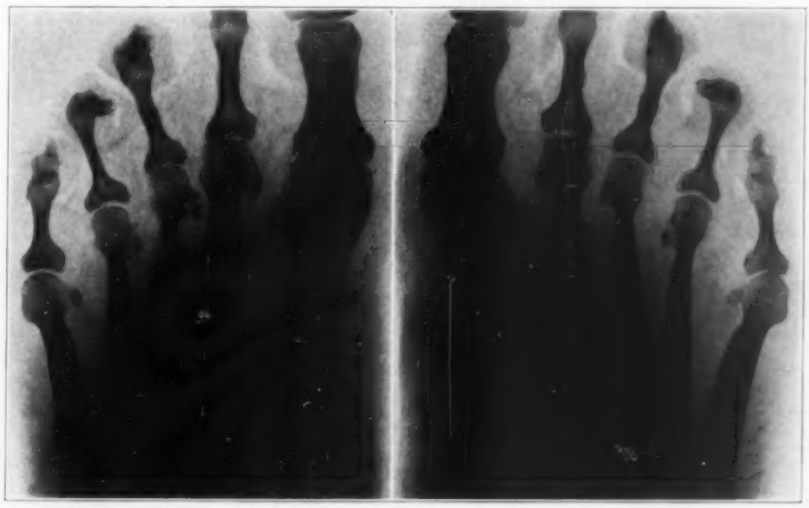

FIG. 1

Roentgenogram of the feet, showing the presence of sesamoids beneath all the toes. At the left third toe there are either two bones or an ununited fracture of the sesamoid.

or more was present at every metatarsophalangeal joint of both feet, as shown by Figure 1. Roentgenograms of the hands showed the presence of double sesamoids at the metacarpophalangeal joints of both thumbs and little fingers, also a single one at the corresponding joint of each index finger.

NOTE: The author wishes to express appreciation to Dr. Glenn Grubb, of Norris, Tennessee, for roentgenograms of this case.

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EWING'S SARCOMA

An Atypical Case with Necropsy Findings

BY HERMAN CHARACHE, M.D., BROOKLYN, NEW YORK

*From the Brooklyn Cancer Institute**

Definitely proved cases of Ewing's sarcoma are relatively uncommon, and those with positive necropsy findings are few in number; therefore, the author feels that the following case will be of interest.

F. B., a white female, eight years of age, was admitted to the Brooklyn Cancer Institute on August 1, 1932, complaining of a swelling of the right side of the face and scalp, weakness, and loss of weight.

In November 1931 pain and swelling in the left knee, not associated with any trauma, had developed. In another hospital a diagnosis of Ewing's tumor had been made and roentgenotherapy had been administered. The pain and swelling had disappeared, and the patient was believed to be cured.

Three months later a small nodule appeared on the head, followed very shortly by a larger swelling in the right parotid region. The patient was then admitted to the Brooklyn Cancer Institute for treatment.

When four years of age she had had some tuberculous glands removed from the neck. Her family history was irrelevant.

On admission, she weighed forty-three and three-fourths pounds; her temperature was 99; the pulse, 90; and respiration, 20.

At the vertex of the scalp was a firm nodule, three by three centimeters, firmly attached to the underlying structures. There was a similar tumor, six by six centimeters, in the right parotid region at the ramus of the mandible.

Chest examination revealed a slight bulging of the right chest posteriorly, close to the base of the scapula. Two areas of dullness and loss of breath sounds were found at both bases posteriorly.

Abdominal examination showed liver enlargement of about two fingerbreadths below the costal margin; the spleen was not palpable, nor were any other masses felt.

Examination of the extremities revealed that the upper fifth of the left tibia was larger than that of the right. There was no evidence of any swelling of the soft tissues.

The urine was not pathological; Bence-Jones protein was absent. Blood examination revealed a marked secondary anaemia and a negative Wassermann.

Roentgenographic examination showed destructive changes with considerable lime-salt absorption and loss of normal structure of bone detail in the upper two inches of the diaphysis of both tibiae and in the lower end of the diaphysis of the right femur just above the epiphyseal line. The skull did not show any pathological change. The same destructive changes were seen in the right mandible. Roentgenograms of the chest revealed a large tumor mass in the mediastinum, partially infiltrating the bases of both lungs.

During the time the patient remained in the hospital, multiple nodules appeared on the scalp, firm and hard at first, later becoming soft and cystic and breaking down, discharging material resembling coffee grounds. A septic temperature, ranging from 99 to 103, developed with a corresponding change in pulse. The patient lost weight very rapidly and died on December 10, 1932.

*Ira I. Kaplan, M.D., Director, Division of Cancer, Department of Hospitals, New York City.

FIG. 1

External surface of calvarium, showing multiple tumors.

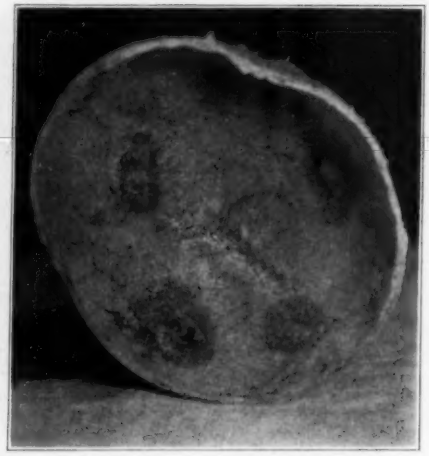

FIG. 2

Internal surface of calvarium, showing penetration of tumors through both tables of skull.

Post-Mortem Examination

The body was shrunken and emaciated, and presented a number of tumefactions in the cranium, in the angle of the jaw, and in the left knee. There were six such tumefactions in the skull, the largest being over the parietal and occipital regions and measuring about four centimeters in diameter. These tumors were not adherent to the scalp, but eroded through the calvarium, forming depressions in the brain with invagination of the dura into the brain substance. A small nodule, measuring two and five-tenths centimeters in diameter, perforated the dura at its attachment near the crista galli, and its pressure tore away the dura from its bony attachment. This nodule made its way into the left inferior frontal gyrus.

FIG. 3

Post-mortem specimen, showing metastatic tumors at the bases of both lungs.

The lungs were compressed and pushed upward by two large grapefruit-like masses which originated in the middle mediastinum and encroached on both lungs, the pericardium, and the pleura. The tumors were soft and somewhat cystic, partially degenerated and liquefied in the center. The surrounding area had the consistency of brain tissue. The tumor in the mandibular region had the same consistency. The periosteum of the left tibia was markedly thickened. The bone marrow had a milk-like consistency. The rest of the organs did not show any gross evidence of malignancy.

The diagnosis of Ewing's sarcoma was confirmed by histological examination of the tumor by Dr. Charles F. Geschickter.

This case is of particular interest as it falls in the atypical group

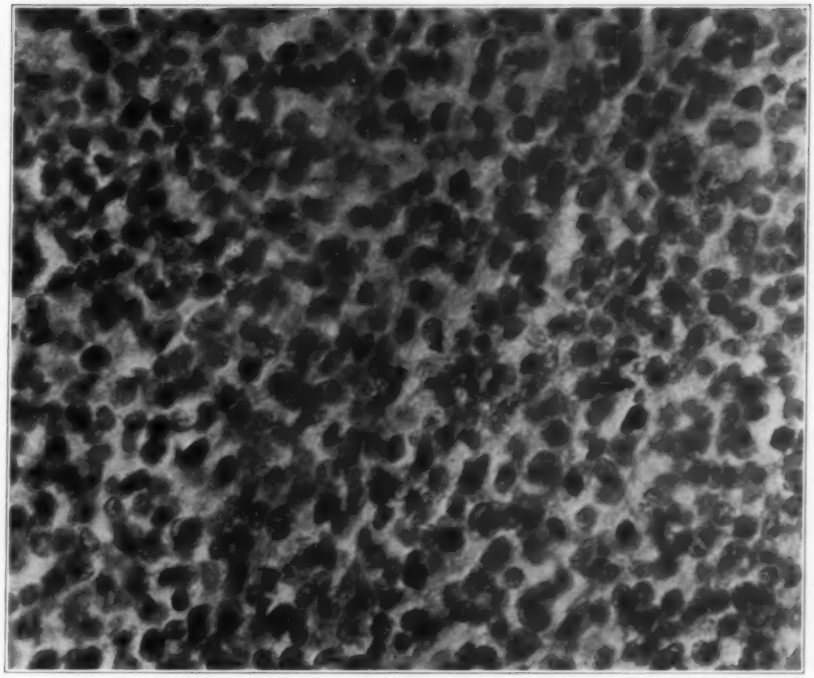

FIG. 4

Photomicrograph, showing lymphoid nature of Ewing's sarcoma.

of Ewing's sarcoma. The tumor invaded the epiphyseal end of the tibia instead of the shaft of the bone, affecting largely the bone-marrow cavity without any marked periosteal changes, as seen in the usual "onion-peel" variety. The skull metastasis in this case is of interest. Geschickter found only one similar case in his series.

Histologically this tumor would tend to prove Geschickter's opinion that Ewing's sarcoma is of lymphatic origin.

NOTE: The author is indebted to Dr. Geschickter for his aid in studying the case and for the photomicrographs which he kindly sent from the Johns Hopkins Hospital.

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A SANITARY FRAME FOR CARE OF CHILDREN IN CASTS

BY DAVID M. BOSWORTH, M.D., NEW YORK, N. Y.

Four years ago, Dr. A. S. Price built the first frame like that shown below for support of his little daughter while she was in plaster following an operation. Its efficiency in making the child comfortable and in keeping her clean and dry was so marked that the support is now used for children in spica casts on the Orthopaedic Services in six hospitals in greater New York. The nursing staffs are universally enthusiastic about it, and it has proved so satisfactory that we felt its publication would be helpful to others; for this reason, the writer is including a diagram with dimensions as well as photographs of its use.

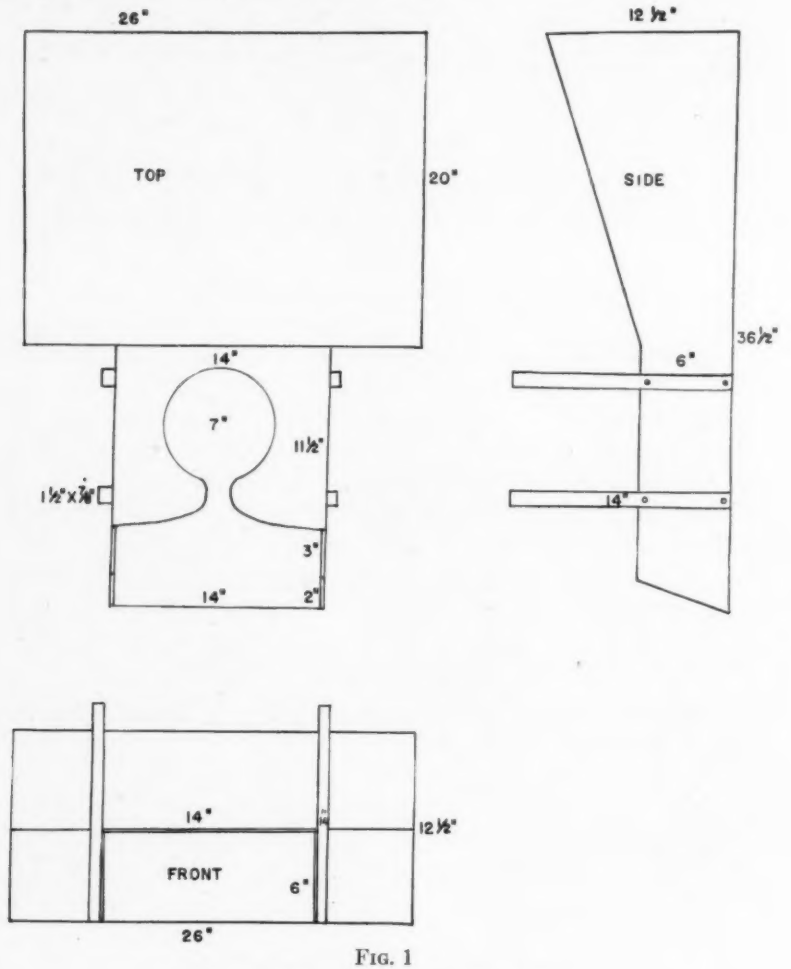

FIG. 1

Plan and dimensions of wooden frame.

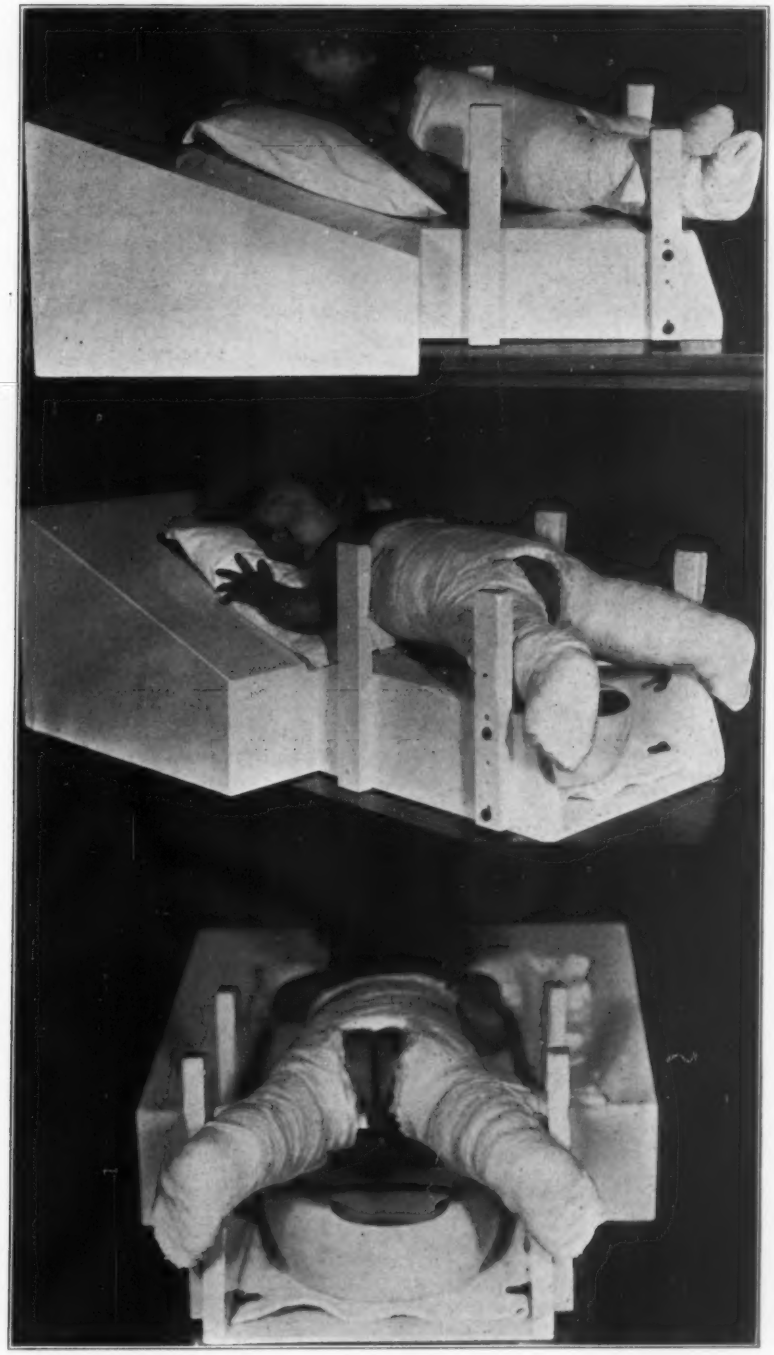

FIG. 2

Child placed on frame on her face and on her back. Note the impossibility of the child's soiling the cast or the dressing under the cast. The lower pegs are fitted with winged nuts on the bolts to provide for placing them inside the frame if a narrower position is desired.

In a case in which the child is very young and one extremity is in plaster, the other extremity is also included during the period of actual treatment, so as to allow for use of the frame. The feet should be included, so that the child does not slide down into the cast. Previous to this, there has been some trouble due to irritation of the upper inner thighs at the plaster margins. With the use of the frame and the double hip spica, fewer complications and infections have resulted from operations about the pelvis, since it is impossible for the child to soil the postoperative dressing. It is likewise impossible for the child to get out of the frame, and the amount of nursing attention necessary to prevent him from falling out of bed is markedly reduced.

SPRENGEL'S DEFORMITY

Report of a Case of Bilateral Involvement

BY S. K. LIVINGSTON, M.D., F.A.C.S., HINES, ILLINOIS

Bilateral failure of the scapula to descend is rather unusual. Bergel found the unilateral deformity in approximately one out of every 3,000 military recruits between the ages of twenty and twenty-two; the deformity occurred more often on the left than on the right. The following case is of interest because of the bilateral involvement.

W. E. M., aged forty years, a farmer, was admitted for diagnosis of an increasing weakness in the arms.

Examination showed an exceedingly well-developed and well-nourished male. The neck was short and powerful, and the head moved on the torso through a normal range. The trapezius, the deltoid, the biceps, and the triceps were especially powerful. The sternum was markedly depressed. The arms could not be raised above the horizontal position, and this position could only be maintained for a short time because of weakness and pain in the scapulae. The scapulae were rotated in such a manner that the vertebral borders, instead of being parallel to the spinal column, were lying closer to the axillae, and the inferior angle nearer the vertebrae. The subscapular angles were more acute than normal. The transverse diameter of the scapulae was greater than the vertical. There were no bony,

Fig. 1

Showing prominence and malposition of the freely moving scapulae and acute subscapular angles.

Fig. 2

Showing marked depression of the sternum.

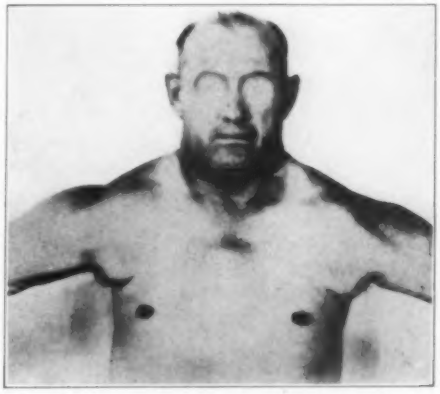

Fig. 3

Compensatory hypertrophy of the musculature of the neck, the shoulders, the back, and the arms. The arms could not be abducted beyond the horizontal position.

cartilaginous, or fibrous connections of the scapulae with the vertebrae; the scapulae moved freely in all planes upon motion of the arms. There did not appear to be any defects of the musculature, ribs, or vertebrae. The powerful muscular development was apparently compensatory for the weakness resulting from the scapular detachment. The Klippel-Feil syndrome did not exist.

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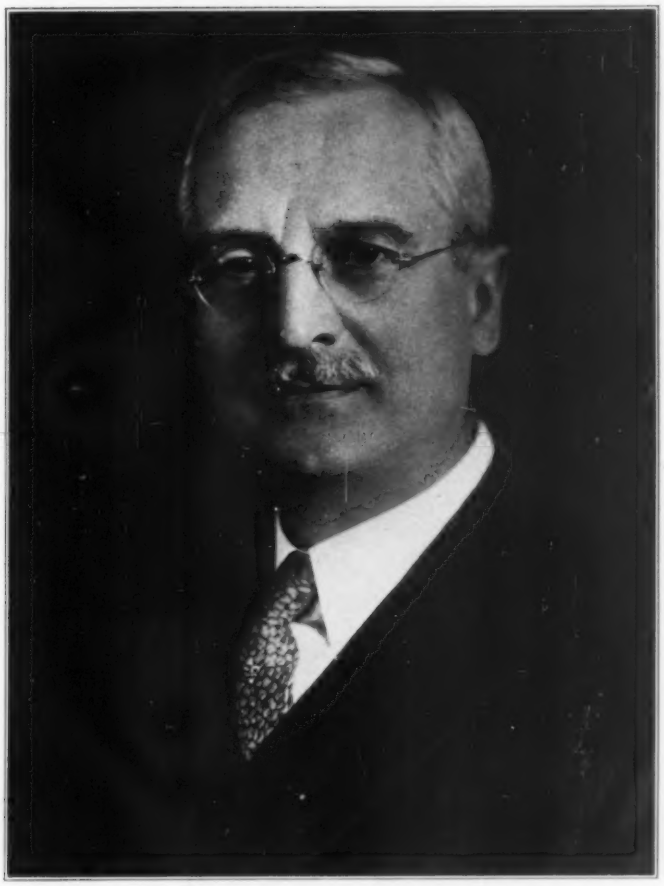

FREDERICK JULIUS GAENSLEN

1877–1937

On March 11, 1937, Frederick Julius Gaenslen died at his home at the age of fifty-nine. In the early afternoon of his life this skilled workman was forced to lay down his tools.

Dr. Gaenslen was born in Milwaukee of German parents who came from Germany in 1870. His training was essentially American, for he obtained his preliminary education in the public schools of Milwaukee. He graduated from the University of Wisconsin in 1899 and received his medical training in Johns Hopkins Hospital, from which institution he took his degree in 1903. After an internship in a New York hospital, he established himself in general medical practice in Milwaukee, which he followed until 1912.

His unusual initiative and ability soon gave him the urge toward a larger field of achievement. He turned to orthopaedic surgery and began his career by studying in Europe. From that time he confined his work to the practice of this branch of surgery. He played an active part in the development of orthopaedic surgery in his section of the country and contributed so largely to the advancement of this specialty that he was considered the Father of Orthopaedic Surgery in Wisconsin and was an outstanding figure in the Middle West. He was a charter member and a past president of the Clinical Ortho-

paedic Society and a member of the American Orthopaedic Association, of which he was President in 1936.

Early travel gave to this earnest student a breadth of vision that helped to develop an excellent judgment and in later years supplied him with whimsical anecdotes and reminiscences. Eager participation in the work of scientific organizations benefited them as well as himself. His discussions from the floor were a delight to the audience. Accurate clinical observation, detailed records, and laboratory experimentation furnished the material from which he drew to enrich the orthopaedic literature. The splendid results of his surgery are monuments to his meticulous technique and attention to detail.

The memory of the man will long endure in the hearts of those who loved him for his human qualities. Through formal lecture and by precept, he instilled in his students the highest ideals of professional attainment. By his untiring energy, consummate skill, and absolute integrity he engendered a respect for orthopaedic surgery which remains as a heritage for those who followed him. His achievement in orthopaedic surgery needs no word of elaboration. The regard of his colleagues is attested by their grief at his passing.

News Notes

The Fifty-First Annual Meeting of the **American Orthopaedic Association** will be held in Lincoln and Omaha, Nebraska, on June 2, 3, and 4, 1937, under the presidency of Dr. H. Winnett Orr. Headquarters will be at the Cornhusker Hotel. Among the foreign guests expected are: Mr. R. Watson Jones, of Liverpool; Prof. Lelio Zeno, of Rosario; Prof. Charles Lasserre, of Bordeaux; and Prof. Juan Farill, of Mexico City. Since this meeting commemorates the Fiftieth Anniversary of the American Orthopaedic Association, a program of special interest has been arranged. The following papers are to be presented:

WEDNESDAY, JUNE 2

Morning Session

Subastragalar Arthrodesis. A New Version of an Old Subject.
Dr. R. Plato Schwartz, Rochester, New York.

Acute Osteomyelitis of the Long Bones in Adults.
Dr. Isadore Zadek, New York City.

Acute Osteomyelitis—Treatment in the Light of Recent Serological Findings.
Dr. D. E. Robertson, Toronto, Canada.

Treatment of Early Slipping of the Femoral Epiphysis.
Dr. Leo Mayer, New York City.

Afternoon Session

Closed Reduction of Fractures of the Neck of the Femur.
Dr. Guy W. Leadbetter, Washington, D. C.

Internal Fixation of Fresh Fractures of the Neck of the Femur.
Dr. M. N. Smith-Petersen, Boston, Massachusetts.

Comments on Internal Fixation of Fresh Fractures of the Neck of the Femur.
Dr. W. W. Plummer, Buffalo, New York.

Reconstruction Operations for Ununited Fractures of the Neck of the Femur.
Dr. E. G. Brackett, Boston, Massachusetts.

THURSDAY, JUNE 3

Morning Session

Synovectomy: Its History to Date.
Dr. Paul Swett, Hartford, Connecticut.

Presidential Address. The Contribution of Orthopaedic Surgery to the Lister Antiseptic Method.
Dr. H. Winnett Orr, Lincoln, Nebraska.

The Development of Fracture Treatment in Great Britain.
Mr. R. Watson Jones, Liverpool, England. (By invitation.)

Experiences with Massive Bone Grafts.
Dr. Dallas B. Phemister, Chicago, Illinois.

Afternoon Session

Dashboard Dislocations of the Hip.
Dr. Robert Funsten, University, Virginia.

History of Orthopaedic Surgery and the American Orthopaedic Association.
Dr. Robert B. Osgood, Boston, Massachusetts.

Federal and State Care of Crippled Children.
Dr. R. C. Hood, Washington, D. C. (By invitation.)

Studies of the Longitudinal Growth of Bone.
Dr. Edward L. Compere, Chicago, Illinois.

On Friday, June 4, the members and guests will leave by special train for Omaha, where a clinical program will be presented at the University Hospital under the direction of Dr. J. P. Lord, Dr. Robert D. Schrock, and their associates.

The first Executive Session will be held on Wednesday, June 2, at 12:00 noon and the second Executive Session will take place on Friday, June 4, at 12:00 noon in Omaha.

On Wednesday evening a studio supper has been arranged for members and guests in Morrill Hall, University of Nebraska, followed by a lecture in the University Museum on "Some Interesting Palaeological Findings in Nebraska" by Prof. E. H. Barbour, Director of the Museum.

At 12:00 noon on Thursday, June 3, there will be a luncheon for the members and guests at the Nebraska State Capitol at which the Guest of Honor will be the Hon. Roy L. Cochran, Governor of Nebraska. The Annual Dinner will be held on Thursday evening at 7:00 o'clock at the University Club.

The Spring Meeting of the **British Orthopaedic Association** is to be held in Copenhagen and Stockholm on May 17 through May 21, 1937.

Many readers of *The Journal* occasionally find among their patients those who are handicapped by deafness. Perhaps all are not familiar with the valuable work which is being done by The Volta Bureau in helping such people to meet their special problems. The Volta Bureau was established by Alexander Graham Bell with money which he received as a prize for inventing the telephone. It was his wish that anyone confronting the problems of deafness might be assured of help. The services of The Volta Bureau are free. Pamphlets dealing with all phases of deafness, except medical problems, are available to all who ask for them. The address of The Volta Bureau is 1537 35th St., N. W., Washington, D. C.

At the last examination of **The American Board of Orthopaedic Surgery,** held in Cleveland on January 9, 1937, ninety-four candidates were certified. The personnel of the Board is as follows:

Dr. Willis C. Campbell, *President*	Representing the American Medical Association
Dr. Edwin W. Ryerson, *Vice-President*	Representing the American Academy of Orthopaedic Surgeons
Dr. Fremont A. Chandler, *Secretary-Treasurer*	Representing the American Medical Association
Dr. George E. Bennett	Representing the American Orthopaedic Association
Dr. Melvin S. Henderson	Representing the American Orthopaedic Association
Dr. Samuel Kleinberg	Representing the American Academy of Orthopaedic Surgeons
Dr. Philip Lewin	Representing the American Academy of Orthopaedic Surgeons
Dr. John C. Wilson	Representing the American Medical Association
Dr. Philip D. Wilson	Representing the American Orthopaedic Association

The next examination of the Board will be held in conjunction with the meeting of the American Medical Association at Atlantic City. Tentative plans call for the examination to be held on June 8. Applications should be in the Secretary's hands at least sixty days before the date of the next examination.

The certificate of this Board has become a prerequisite for membership in the American Academy of Orthopaedic Surgeons. The members of the American Orthopaedic Association, who have been exempted from examination heretofore, will be required to take the examination after July 1, 1937.

FREMONT A. CHANDLER, M.D., *Secretary*

The Fifth Annual Convention of **The American Academy of Orthopaedic Surgeons** was held in Cleveland, Ohio, on January 10, 11, 12, 13, and 14, 1937, under the presidency of Dr. Melvin S. Henderson. The attendance at this meeting was 787.

An exceptionally interesting program was presented, the details of which were published in the January issue of *The Journal*. Of especial interest were the seminars on the following subjects: "Shoulder Lesions", conducted by Dr. E. A. Codman, Boston; "Osteomyelitis", led by Dr. H. Winnett Orr, Lincoln; "Fractures of the Ankle", under the chairmanship of Dr. Philip D. Wilson, New York; and "Low-Back Lesions", led by Dr. Joel E. Goldthwait, Boston.

Five radio broadcasts were given in connection with the meeting as follows:

The Accomplishments of Orthopaedic Surgery.
Dr. Melvin S. Henderson, Rochester, Minnesota.

Physically Handicapped Children and Adults.
Dr. Edwin W. Ryerson, Chicago, Illinois.

Infantile Paralysis.
Dr. Albert H. Freiberg, Cincinnati, Ohio.

Recent Advances in the Causes and Treatment of Arthritis.
Dr. Robert B. Osgood, Boston, Massachusetts.

The Fracture Situation.
Dr. Willis C. Campbell, Memphis, Tennessee.

There were fifty scientific exhibits. The Gold Medal was won by Dr. R. Plato Schwartz and his associates, of Rochester, New York, for their exhibit on "Pathology of Gastrocnemius and Soleus Muscles and Tendo Achillis". The Silver Medal was presented to Dr. Weston A. Price, of Cleveland, Ohio, for his exhibit on "Field Studies among Primitive Races with Reference to Bone Development and Dental Caries". The Bronze Medal was given to Dr. Edgar Oppenheimer, of New York City, for his exhibit on "Apparatus for Fracture Management".

Certificates of Merit were awarded to the following men for the excellency of their scientific exhibits:

Dr. Willis C. Campbell Clinic, Memphis, Tennessee:	Endothelial Myeloma (Ewing Tumor). Ununited Fractures—Onlay Bone Graft.
Dr. Michael S. Burman, New York City:	Curare in Spastic Paralysis. The Spastic Hand. Certain Other Kinesiological Disturbances of the Hand.
Dr. Henry Milch and Dr. Maurice M. Pomeranz, New York City:	Upper Femoral Epiphysiolysis.
Dr. Earl D. McBride, Oklahoma City, Oklahoma:	Scoliosis. A New Derotation Apparatus and New X-Ray Method of Recording.
Dr. Keene O. Haldeman, San Francisco, California:	The Healing of Bone Following Injury and Infection.
Dr. James A. Dickson, Cleveland, Ohio:	Torticollis. Experimental and Clinical Studies.

The exhibits of the following were considered worthy of special mention: Dr. T. Wingate Todd, Cleveland, Ohio; Dr. Fred H. Albee, New York City; Dr. J. Warren White, Greenville, South Carolina; Dr. Roger Anderson, Seattle, Washington; and Dr. J. E. M. Thomson and Dr. C. Fred Ferciot, Lincoln, Nebraska.

The officers for the ensuing year are:

President: Dr. A. Bruce Gill, Philadelphia, Pennsylvania.
President-Elect: Dr. John C. Wilson, Los Angeles, California.
Vice-President: Dr. Philip Lewin, Chicago, Illinois.
Treasurer: Dr. E. Bishop Mumford, Indianapolis, Indiana.
Secretary: Dr. Carl E. Badgley, Ann Arbor, Michigan.

The next meeting will be held in Los Angeles, California, on January 16, 17, 18, 19, and 20, 1938.

In connection with the meeting of the **American Medical Association** at Atlantic City, June 9, 10, and 11, the following program has been arranged for the Section on Orthopaedic Surgery.

WEDNESDAY, JUNE 9

Comparison of Treatments and Their Results in Fractures of the Shaft of the Femur.
Dr. E. L. Eliason, Philadelphia, Pennsylvania.
End Result of Twenty-One Years of Spine Fusion for Tuberculosis.
Dr. W. H. Von Lackum, New York City.
The Etiology of Cartilaginous Exostoses and Giant-Cell Tumors of the Bone.
Dr. J. Dewey Bisgard, Omaha, Nebraska.
The Dynamic Biological Relativity of Nerve, Muscle, and Bone Pressure during Growth and Maturity.
Dr. Eben J. Carey, Milwaukee, Wisconsin. (By invitation.)
The Importance of Adequate Fracture Treatment in Rural Hospitals.
Dr. W. T. Hammond, Easton, Maryland.
A Comparative Study of the Surgical and Non-Operative Methods of Treating Bone and Joint Tuberculosis.
Dr. Leo Mayer, New York City.

THURSDAY, JUNE 10

Intervertebral-Disc Lesions.
Dr. W. J. Mixter, Dr. J. S. Barr, and Dr. A. O. Hampton, Boston, Massachusetts.
The Neurological Significance of Low-Back Pain.
Dr. R. G. Spurling and Dr. F. H. Mayfield, Louisville, Kentucky.
The Relation of Fascia Lata to Low-Back Conditions.
Dr. Frank R. Ober, Boston, Massachusetts.
Differential Diagnosis in Low-Back Pain.
Dr. Arthur Steindler, Iowa City, Iowa.
Arthrodesis in Osteo-Arthritis of the Hip.
Mr. R. Watson Jones, Liverpool, England. (By invitation.)
The Treatment of Chronic Arthritis of the Foot.
Dr. John G. Kuhns, Boston, Massachusetts.

FRIDAY, JUNE 11

Pathological Fractures.
Dr. Ralph K. Ghormley, Rochester, Minnesota.
The Occurrence of an Osseous Dyscrasia in Gastrectomized Puppies.
Dr. A. C. Ivy, Chicago, Illinois.
Dr. R. A. Bussabarger and Dr. Smith Freeman, Chicago, Illinois. (By invitation.)
Malunited Colles' Fractures.
Dr. Willis C. Campbell, Memphis, Tennessee.
Chairman's Address.
Dr. Fremont A. Chandler, Chicago, Illinois.
Simplified Technique of Onlay Grafts for All Ununited Fractures in Acceptable Position.
Dr. D. B. Phemister, Chicago, Illinois.
Fractures of the Os Calcis.
Dr. H. W. Spiers, Los Angeles, California.

The Chairman of the Section on Orthopaedic Surgery is Dr. Fremont A. Chandler, Chicago, Illinois, and the Secretary is Dr. Robert V. Funsten, University of Virginia Hospital, University, Virginia, to whom all requests for information should be addressed.

On February 11, 1937, Mr. Walter Mercer, M.B., Ch.B., F.R.C.S. (Edin.) F.R.S. (Edin.), of Edinburgh, delivered The **Lady Jones Lecture** in Orthopaedic Surgery at the University of Liverpool. The title of Mr. Mercer's address was "Anomalies of the Fifth Lumbar Vertebra: Reflections and Experiences".

Under the auspices of the **Gesellschaft der Ärzte in Wien** and the **Verein zur Förderung des ärztlichen Fortbildungswesens an der Universität Wien** an "*Ärztliche Festwochen*" has been arranged. This celebration takes place from May 19 to 29 and marks the one-hundredth anniversary of the founding of the former Society. Courses of lectures covering all branches of medicine will be given. Of interest to orthopaedic surgeons will be the addresses of Prof. Dr. F. v. Müller, of Munich, on "The Arthritic Diathesis" and Prof. Dr. E. Payr, of Leipzig, on "The Chief Methods of Overcoming Hypertension in Injuries and Diseases of the Joints".

The Annual Meeting of **La Réunion d'Orthopédie et de Chirurgie de l'Appareil Moteur de Bordeaux** was held on November 26, 1936, at which time members and guests presented papers on subjects of particular interest to the orthopaedic and the traumatic surgeon. The following papers were presented:

Extra-Articular Arthrodesis of the Hip in the Treatment of Coxalgia—Dr. H. L. Rocher.

Recurrent Fracture of the Patella—Dr. Ch. Lasserre.

Arthrodesis of the Tibiotarsal Articulation in Post-Traumatic Arthritis—Dr. Ch. Lasserre.

Platyspondylisis—Dr. R. Guerin.

Myeloplaxoma of the Axis—Dr. Y. Bourde (Marseilles).

Complicated Fractures of the Leg—Dr. Pr. Roques (Marseilles).

Two Cases of Malunited Fracture Treated Surgically—Dr. Charry (Toulouse).

Osteochondroma of the Knee—Dr. Ch. Lasserre and Dr. Dotezac.

Congenital Atrophy of the Spinous Apophyses—Dr. Ed. Papin.

Treatment of Epiphysiolysis—Dr. H. L. Rocher, Dr. R. Guerin, and Dr. L. Pouyanne.

Double Sacro-Iliac Arthrodesis—Dr. Charbonnel and Dr. Masse.

Pes Cavus Treated by the Phelps-Salaverri Operation—Dr. L. Pouyanne and Dr. H. L. Rocher.

Coxitis and Congenital Lesions—Dr. P. Forton.

Recurrent Luxation of the Patella—Dr. R. Dieulafé (Toulouse).

Amputation of Both Forearms in a Fourteen-Year-Old Boy and Condition of the Patient After Four Months of Reeducation—Dr. Dijonneau.

These papers have been published in the *Journal de Médecine de Bordeaux et du Sud-Ouest*, the issue of February 20, 1937.

The following have been elected to membership in the Society:

Honorary Member: Dr. Oudard, Toulon.

Corresponding Members: Dr. Solcard, Toulon; Dr. Roques, Marseilles; Dr. Clavelin, Val de Grace.

CORRECTION

Dr. Henry Milch of New York has asked us to publish the following:

"In my recent article on Epiphysiolysis, in the January issue for 1937, page 114, a statement to the following effect appears:

> "'While the early results appear quite satisfactory, the method must not be considered entirely innocuous, since in one case calcification of the capsule with complete loss of all motion was the outcome of the operation.'

"It has been called to my attention that the calcification of the capsule in the case mentioned was improperly attributed to the drilling and was, in truth, due not to drilling, but to manipulation and other procedures.

"I regret that this inaccuracy should have appeared in my article, which, of course, was concerned primarily with the interpretation of the wide epiphyseal line, rather than the indications for, or the value of, any specific therapeutic measures."

Current Literature

PHYSIOLOGIE GÉNÉRALE DES ARTICULATIONS À L'ÉTAT NORMAL ET PATHOLOGIQUE (General Physiology of Normal and Pathological Articulations). A. Policard, Paris, Masson et Cie, 1936. 36 francs.

As a consequence of the efforts of many observers, a vast amount of information on the form and functions of specific joints has been accumulated. Unfortunately, most of these data are scattered in journals not readily accessible to the orthopaedic surgeon to whom they are of vital and incalculable importance. The author has culled the more significant of these contributions with the object of establishing the anatomy and physiology of "an articulation in general, the tissues which constitute it, the fundamental mechanics which play their part in it, the conditions of its nutrition".

The present volume, consisting of 209 pages, is subdivided into seven chapters which treat specifically of the articular cartilage, the accessory fibrocartilages, the synovial membrane, the joint proper and the synovial fluid, the capsule and the articular ligaments, the innervation of the joint, and the periarticular connective tissue. The first chapter on the articular cartilage is based largely upon the work of Benninghof and gives an excellent discussion of the minuter structure and histophysiology of hyaline cartilage. The relative importance of the intracellular substance and of the fibrillar network which determines the essential physiological value of the hyaline cartilage is described with painstaking detail. The nutrition, the functional destruction of the hyaline cartilage, its normal histomechanics, the question of the growth and regeneration of adult cartilage, and, finally, the pathological processes of fissuring, softening, and chondromalacia are each treated with characteristic French lucidity and brevity. The chapters on the synovial membrane and the synovia, in which the author follows the work of Hammar, are almost, if not quite, as stimulating as the earlier part of the work. Throughout the author stresses the fact that in their anatomical arrangement, in their physiological adaptation, and in their pathological reaction, the joint and the synovial membrane betray their connective-tissue, mesenchymal origin. It is only upon the acceptance of this fundamental concept that the various data can be unified and assimilated.

It is to be regretted that in these, as in the other portions of his work, the emphasis has been laid more upon the normal biology of the joint, while only relatively slight space has been allotted to a sketchy outline of pathological conditions. It is further to be regretted that several additional drawings to clarify the textual description of the anatomy at transition points—*e.g.*, between the hyaline cartilage and the synovial membrane—have not been given. But these few faults are more than compensated for by a terse, but freely flowing literary style which is as exhilarating in elucidating what is already known as in indicating problems yet to be solved. To the orthopaedic surgeon, almost overwhelmed by a rapidly accumulating mass of detail, this volume will come as a sort of intellectual oasis in which he may refresh himself by substituting broad, general principles for the minutiae of daily application.

THE PHYSIOLOGICAL BASIS OF MEDICAL PRACTICE. Charles Herbert Best, M.D., D.Sc. (Lond.), F.R.S., F.R.C.P., and Norman Burke Taylor, M.D., F.R.S., F.R.C.S. (Edin.), F.R.C.P., M.R.C.S. (Eng.), L.R.C.P. (Lond.). Baltimore, William Wood & Co., 1937. $10.00.

The subtitle to this very complete text-book is "A University of Toronto Text in Applied Physiology". In the preface the authors state: "We have endeavored to write a book which will serve to link the laboratory and the clinic, and which will therefore promote continuity of physiological teaching throughout the preclinical and clinical years of

the under-graduate course." This is in keeping with modern tendencies in medical teaching. No student in a four years' medical course can digest the vast amount of knowledge which has accumulated in the basic medical sciences. What particularly concerns him in his future practice must be extracted for him at the cost of his formal knowledge.

As a text-book of 1519 pages, written for medical students whose chief interest is assumed to be in the diagnosis and treatment of disease, it errs possibly on the side of being too massive. Starling's "Human Physiology" has been criticized for the same reason. An excellent feature is the inclusion of short descriptions of diseases with their physiological background. It is modern in the sense that it includes, for example, considerations of the sedimentation rate of red blood cells, of the action of methylene blue in cyanide poisoning, of protamine insulin, of obesity, and of female sex hormones. An excellent section of 303 pages on the nervous system is included. Students preparing for examinations will be grateful for the terse description of Horner's syndrome. Such a treatise, covering all systems of the body with a double purpose, may not please every reader. For example, some would prefer a more complete handling of the modern knowledge of ascorbic acid, and many would not agree that the influence of the spleen in regulating blood volume in man is of as great importance as the authors indicate.

The book is written carefully and makes pleasurable reading. The touch of sober drama—the descriptions of Head's experiment upon himself, and of Lind's research on scurvy in 1747—is not a disadvantage. This will unquestionably become an important text-book in many medical schools. It will be very useful to the practitioner of medicine who is desirous of keeping up to date his theoretical knowledge and of applying physiological principles in his practice.

DIE PYOGENEN INFEKTIONEN UND IHRE BEHANDLUNG (Pyogenic Infections and Their Treatment). Erich Lexer. (Neue deutsche Chirurgie, 56. Band.) Stuttgart, Ferdinand Enke, 1936. 12.80 marks.

Lexer reiterates his classification of conditions familiarly referred to as "sepsis", "septicaemia", and "pyaemia". Excluding putrid and specific infections, he supplants such vague terms by classifying generalized pyogenic infection, whose cause is usually staphylococcal or streptococcal, into forms with and without metastases. The metastatic form is either purely bacterial or thrombo-embolic; that without metastases, either bacterial or toxic. Treatment is directed toward removal of the infecting agent and increased resistance of the host. Discussion of this occupies the first part of the book and is taken from his work on generalized pyogenic infections and their treatment, reviewed in the January 1937 issue of *The Journal of Bone and Joint Surgery*.

Localized pyogenic infections are to be treated by excision of the tissue boundaries of the affected area within the limits of bacterial incubation time, most often from six to eight hours. Lexer states that there are four primary principles to be borne in mind in attacking and checking the spread of localized pyogenic infections: (1) increase of general resistance; (2) reenforcement of local defense processes; (3) operative exposure of the sources of infection,—primary and secondary, lymphatic and hematogenous; and (4) immobilization of the affected regions.

Generalized resistance is best increased by blood transfusion. Antiserums, vaccines, bacteriolysins, non-specific protein therapy, creation of a sterile abscess, and chemotherapy may be of more value when the infection is still localized than when it has become generalized.

Reenforcement of local tissue defense is gained in many cases through Bier's passive hyperaemia. On the other hand, active hyperaemia is useful following regression of the acute stage. Although less useful in suppurative osteomyelitis, the x-ray has been seen to cause regression of simple periosteal abscesses before roentgenographically visible bone changes occur.

For the third principle, "the earlier and the better the first inflammatory areas are

exposed, the more reliable will be recovery and the more safely will latent sources of infection be avoided". Coagulation of an infective area by heat or by electricity is criticized; electrosurgical incision may be superior to simple incision and requires no tourniquet ischaemia. Spread of infection through early exposure does not occur when the incision does not infringe on the zone of protective reaction; the incision should be lightly packed with iodoform gauze for twenty-four hours, with or without drainage tubes, to promote capillary drainage.

The principle of immobilization and rest with elevation of the affected region is of the utmost importance. Dressings may be changed as often as necessary, but with minimal disturbance of the wound surface and the protective barrier of granulation tissue.

Lexer then discusses the therapy of certain forms of pyogenic infection,—suppurative arthritis and pyogenic infections of bone, the lymphatic channels, and serous cavities.

The observations which Prof. Lexer is able to give from his long and varied experience will serve as a valuable guide to any surgeon who has to deal with these problems.

LOMBOARTRITE E SCIATICA VERTEBRALE. V. Putti. Bologna, L. Cappelli, 1936.

Within the short span of one year, Prof. Putti has added to his excellent work on the pathology of the congenital dislocation of the hip a no less remarkable monograph on the lumbosacralgias or low-back pain. It is the result of twenty years' observation and study of 1121 cases.

Following his conception of "neurodokitis", the author gives a detailed consideration of the anatomy of the nerve supply to the intervertebral canal and intervertebral articulations. With a great deal of plausibility he rejects the older ideas of the significance of the transverse process and sacralization. If sacralization causes disturbance, it is the effect of arthritis in the newly formed articulation. He thinks the same of the so called tropism. On the other hand, an ordinary acute lumbago is an eminently articular syndrome, not a muscular syndrome. He also speaks of a definitely traumatic lumbago of sudden onset, as distinct from the arthralgic form. There is a lumbalgia entirely confined to the back, exquisitely localized, in contrast to the radiating form of sciatica. Instructive roentgenograms and anatomical specimens, showing definite osteo-arthritic changes of the intervertebral articulations, are included. He discusses in detail the sciatic scoliosis which he ascribes to a vertebral unilateral arthritis. He takes issue with Sicard's conception of radiculitis in cases in which the roentgenogram shows arthritic changes in the articulations, believing that the latter are the principal causes of the pain syndrome. He gives statistics on reflex changes (deep 30 per cent., superficial 0.89 per cent.), motor disturbances (8.5 per cent.), and muscle atrophy (51.56 per cent.), and discusses the differential diagnosis of intraspinous lesions, spondylosis, Pott's disease, tumors, sacro-iliac disease, hip disease, etc.

In the chapter on treatment, physical therapy, especially hot-air treatment, is emphasized, while diathermy and short-wave treatment are strongly rejected. As he has done in previous publications, the author again emphasizes immobilization by cast as the paramount measure. No place is given to manipulation. On the operative side, he mentions and describes with the aid of excellent illustrations the transversectomy for painful sacralization and the technique of the resection of a posteriorly herniated intervertebral disc. A short chapter is devoted to cervicothoracic brachialgia.

The book is magnificently illustrated. The anatomical and pathological material underlying this study is not only abundant but it is also utilized with painstaking care and thoroughness. The reader will be strongly attracted by the brilliancy of diction and clearness of presentation. The work is a milestone in the study of low-back disorders.

RECENT ADVANCES IN ORTHOPAEDIC SURGERY. B. H. Burns, F.R.C.S., and V. H. Ellis, F.R.C.S. Philadelphia, P. Blakiston's Son & Co., Inc., 1937. $5.00.

This interesting volume of moderate size makes some attempt to bridge the gap between the text-book on orthopaedic surgery and the more recent literature. There is no

attempt to bring the knowledge of *all* the various orthopaedic diseases up to date and in certain notable instances the omissions are really glaring. For instance, the chapter on Anterior Poliomyelitis dismisses tendon transplantation with a few lines, which suggests that this procedure has fallen into disrepute. The only operative procedure specifically described in this chapter is Lambrinudi's modification of the triple arthrodesis for foot stabilization.

However, the reviewer found the discussion of most of the topics to be fresh, interesting, and sane, and he predicts that the reader will be repaid by discovering some "recent advances" which had previously eluded his attention.

The purpose of the book seems to be stated in these lines quoted from the preface: "Our views will, we hope, be helpful to some, whilst to others they may be an irritant, perhaps amounting to a stimulus". Their hopes will, the reviewer believes, be realized.

QUELQUES VÉRITÉS PREMIÈRES (OU SOI-DISANT TELLES) EN CHIRURGIE INFANTILE. L. Ombrédanne. Paris, Masson et Cie, 1936. 24 francs.

In his daily clinical experience, the busy surgeon is constantly making observations, the accumulation of which form the basis of his increasing skill and judgment. This capacity of observation in forming an estimate of the value and significance of the signs and symptoms should be a part of the self training of every medical man. Very few, however, put themselves to the task of recording their ideas and their observations as they are made, so that their experience may be available to those who have less opportunity.

The author of this book has evidently applied himself to this task throughout a long experience, and has put into brief and almost axiomatic form certain truths which can be applied to the subject of the surgery of children. The book serves to emphasize many of these facts which are accepted, and to correct other conceptions which are not accurately founded. The author states that the truths of today may become the errors of tomorrow. The observations cover practically the whole field of the surgery of children, and they are grouped under the following headings: Generalities; Face and Neck; Head and Spine; Thorax and Abdomen; Genital Organs; and Limbs.

This book will be of great interest to those who have already had a great deal of experience, and of much help to those who have had less.

SOURCE BOOK OF ORTHOPAEDICS. Edgar M. Bick, M.A., M.D. Baltimore, The Williams & Wilkins Co., 1937. $4.00.

From a very extensive study of the literature of the world, Dr. Bick has given a most comprehensive story of the development of Orthopaedic Surgery, correlating from the earliest data on primitive man and his accomplishments the factors which have influenced the beginning and the rise of this special branch of Medicine. It is interesting to read of the struggles in that period and of the ingenuity shown in the use of the most primitive material, and with instinct instead of knowledge to guide. By grouping the results of his study into periods, the author demonstrates the gradual unfolding of this specialty and gives a glimpse of the changing opportunities in the different periods. The prominence given the facilities possible at that time in the treatment of fractures indicates the importance of these injuries in those early and troublesome times when the mere existence depended on protection by physical force. Under the more highly developed intellectual periods, art and the refined influences are shown to have played an important rôle.

The latter part of the book deals with the influence of the important factors on the growth of the special departments of Orthopaedic Surgery, and tribute is paid to those men whose special contributions toward the advancement of Orthopaedic Surgery made them famous for all time. Some of the more important problems, which are now prominent and are given more special attention, are discussed separately and in detail. This helps to set forth more clearly the present status of this specialty.

The book is so written that it makes enjoyable reading, and its thorough treatment of the subject gives satisfaction.

PREOPERATIVE AND POSTOPERATIVE TREATMENT. Robert L. Mason, A.B., M.D., F.A.C.S. Philadelphia and London, W. B. Saunders Co., 1937. $6.00.

The writer believes that "the good surgeon is primarily a good physician". Here is a surgical treatise of 495 pages without a word on surgical technique. Good preoperative study and treatment and proper postoperative treatment make the difference between poor and good surgery. The rapid developments in this field during the past decade warrant just such a book.

The plan and the arrangement of the material are excellent. The chapter on anaesthesia and the position of the patient on the operating table is especially well illustrated. Throughout the book the cuts and line drawings are good. Proper emphasis is laid on the various subjects treated and the book is well balanced. Certain chapters are written by specialists in their subjects,—an anaesthetist, internists, a cardiologist, a thoracic surgeon, a proctologist, a urologist, etc. These specialists have not only written sections on their subjects as a whole, but, in the second half of the book, they have written sections directly under the treatment of regional conditions. Such an arrangement emphasizes the fact that a good surgeon needs the assistance of such men throughout the course of the surgical treatment. As an example, the cardiologist and the diabetic internist have assisted in writing the section on the preoperative and postoperative care of the patient with hyperthyroidism.

The book opens with preliminary considerations of the history, physical examination, and laboratory studies. Then follow discussions on the conditions affecting the operative risk, the management of patients with heart disease, diabetes, hypertension or nephritis, anaesthesia, and the general preparation of the good-risk patient. Shock, transfusion, water balance and methods of administering fluids, adynamic ileus, and acute dilatation of the stomach are also considered. The care of the wound, the reasons for disruption of wounds, pulmonary complications, peritonitis, parotitis, thrombosis, and the treatment of burns are carefully described. In the second half, treatment is discussed under regions and specific conditions, as intestinal obstruction, appendicitis, hyperthyroidism, and urology.

THE HOME TREATMENT OF SPASTIC PARALYSIS. Percy Merritt Girard, M.D., F.A.C.S. Foreword by Earl R. Carlson, B.A., M.S., M.D. Philadelphia, J. B. Lippincott Co., 1937. $2.00.

This small volume of Dr. Girard's and its foreword by Dr. Carlson will come as a great boon to many a parent confronted with a problem that calls for a most discriminating understanding of child psychology, as well as the most persistent attention to the training of the unfortunate child, not merely in trying to educate refractory muscles, but in teaching him to forget his handicap, thus preventing the closure of channels for improvement, both mental and physical, that must go hand in hand. Better physical control, desirable as it is, will fall far short of what it might mean to the individual if at the same time areas of the brain, dependent upon stimuli that must come to them through impaired peripheral organs, are not specially cultivated.

The different subdivisions of the subject are adequately handled. Physical therapy, as applied to specific disabilities and deformities, is well considered and outlined. Occupational therapy, games, speech training, and methods of teaching relaxation and coordination are given their proper values and the attitude of parents and attendants toward the spastic and his or her attitude toward other children and society at large are properly emphasized.

This book should fill a long-felt want,—a want, it is to be feared, not as fully appreciated as it should be on the part of many physicians and others who are called upon to deal with these problems.

THE KINESIOLOGY OF CORRECTIVE EXERCISE. Gertrude Hawley, M.A. Philadelphia, Lea & Febiger, 1937. $2.75.

This book is planned as a practical text-book for those who are actually engaged in the problems of physiotherapy. The author has recognized the difficulties which are encountered in the daily routine of this work and the necessity of a more thorough understanding of the anatomy and of the normal function of the joints which have to do with this form of therapy. She has given a very excellent presentation of these subjects, with the object of aiding those engaged in this work to a better understanding of the application of the exercises which may be used. She has also recognized the difficulties in the choice of exercises given for the various conditions.

The second portion of the book is devoted to the presentation of the clinical part of the problem. It is helpful to have the object of the exercises defined, and to have the exercises for each condition described and grouped according to their use. These exercises are well illustrated by line drawings. Scoliosis and visceroptosis are each accorded a chapter, which places proper emphasis on the importance of these two subjects in the field of physiotherapy.

The author has evidently included many of her own methods and, although the treatment is quite definitely mapped out, it is not enough so to lead the physiotherapist to assume too much of the medical responsibility. The book presents much useful information which is fundamental to the physiotherapist, and contains many helpful suggestions.

JUVENILE PARESIS. William C. Menniger, M.D. The Menniger Clinic Monograph Series No. 1. Baltimore, The Williams & Wilkins Co., 1936. $3.00.

Juvenile paresis is a rare disease but one of considerable importance to the neurologist and the pediatrist. This monograph is a study of forty-three cases from the Menniger Clinic with 610 cases from the literature.

The subject is treated in a thorough manner, in orderly fashion, and written in a style easy to read. The chapter on "Physical Complications, Stigmas, and Endocrinopathies" is especially interesting. Treatment and pathology are discussed at length, and the section on pathology has some excellent illustrations. At the end of the monograph is a complete bibliography of 530 references.

INHALATION ANESTHESIA. A FUNDAMENTAL GUIDE. Arthur E. Guedel, M.D. New York, The Macmillan Co., 1937. $2.50.

Dr. Guedel, Associate Clinical Professor of Surgery (Anaesthesia) at the University of Southern California School of Medicine, has developed a valuable guide to the principles and practice of inhalation anaesthesia for the teachers of anaesthesia, graduate and under-graduate medical students, and physicians, specialists, or general practitioners. In this book may be found the answers to many problems arising in the general care of the patient in anaesthesia.

The book is divided into two parts: the principles of inhalation anaesthesia and anaesthesia accidents.

In the first part is a valuable detailed analysis of the physical signs of inhalation anaesthesia. Following this are discussions of the surgical reflexes, the potency of the various anaesthetic agents, the choice of pre-anaesthetic drugs, the preparation of the patient, and the selection of the anaesthetic agents.

In the second part of the book, Dr. Guedel covers the anaesthetic accidents quite completely. These include: changes in blood pressure, ventricular fibrillation, central and peripheral respiratory paralysis, reflex spasm, aspiration of debris, cyanosis, and anaesthetic explosions. The sources and prevention of anaesthetic explosions are also discussed.

This book gives the reader information on the principles of inhalation anaesthesia which he can readily put into practice.

The *Journal* wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Anales de Cirugía (Rosario), II, No. 4, 1936.

Boletim da Secretaria Geral de Saude e Assistencia (Rio de Janeiro), II, Núm. 4, 1936.

Bulletin of the National Tuberculosis Association, XXIII, Nos. 1 and 3, 1937.

The Child (Washington, D. C.), I, No. 6, 1936; Nos. 7 and 8, 1937.

Cirugía y Cirujanos (Mexico, D.F.), IV, Núms. 5 and 6, 1936; V, Núm. 1, 1937.

Cleveland Clinic Quarterly, IV, No. 1, 1937.

Current Medicine, IV, No. 2, 1937.

Diabetes und Chirurgie. Prof. Dr. A. W. Fischer. (Vorträge aus der praktischen Chirurgie, 12. Heft.) Stuttgart, Ferdinand Enke, 1937.

The Piedmont Hospital Bulletin, X, No. 1, 1937.

Social Statistics (The Child, Supplement No. 1), 1937.

Staphylococcus Stones. A Clinical Study of 90 Cases. John Hellström. (Acta Chirurgica Scandinavica, LXXIX, Supplementum XLVI.) Stockholm, 1936.

Surgery, I, No. 1, 1937.

Zur Frage der Hydronephrose bei Nierengefässvarianten unter besonderer Berücksichtigung ihrer Behandlung durch Gefässresektion. Seved Bergendal. (Acta Chirurgica Scandinavica, LXXIX, Supplementum XLV.) Lund, 1936.

On the Anatomy and Pathology of the Hip-Joint. Poul Morville. *Acta Orthopaedica Scandinavica*, VII, 107, 1936.

Flat acetabulum has been suggested as a cause of hip disorders by several writers and by Dr. Morville in a previous paper (*Acta Orthopaedica Scandinavica* IV, 133, 1933). His present paper is based on the injection of the hips of twelve stillborn babies, and a study of the roentgenograms of 100 patients with osteo-arthritis and of thirty patients who were admitted for hypertrophied prostates.

The femoral head is normally too large for the shallow socket at birth. The progressive deepening of the acetabulum, the changes in the axis of the neck, and the position of the epiphysis are shown diagrammatically from birth to nine years. Instead of the term "congenitally flat acetabulum", the writer suggests the phrase "acetabulum which remains flat".

He further groups hip lesions into constructive (luxation, subluxation, and coxa valga) and structural (coxa plana, "slipping" epiphysis, and acquired subluxation). Osteo-arthritis of the hip is developed on the basis of subluxation of the congenital or of the acquired type. Examples are given, and the treatment is discussed.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

On the Treatment of Tuberculous Spondylitis in Children. H. Wahren. *Acta Orthopaedica Scandinavica*, VII, 177, 1936.

Twenty-four cases of tuberculosis of the spine of children under fourteen years of age were observed for from two to fourteen years following the dates of the fusion operations. The patients were kept in plaster beds until the lesions were no longer progressive and were then operated upon according to Albee's technique. After from two to three months more on plaster beds, plaster jackets were supplied. In most of the cases the patients were supported also by leather jackets.

One child of seven years died immediately following the operation, and one of eight years, three years after the operation. The remaining results are tabulated as: good, fifteen; fair, two; and bad, one. There were five cases of fracture of the graft and two of fracture of the tibia. Further progress of the lesion followed the operation in three cases. A relationship between kyphosis juvenilis and tuberculous spondylitis was suggested by one case in which typical wedging of the thoracic vertebrae was observed six years following the fusion operation at fifteen years of age.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

SYNOVIAL SARCOMA. Leila Charlton Knox. *The American Journal of Cancer*, XXVIII, 461, Nov. 1936.

The author carefully reviews the literature of this rare tumor and collects nineteen cases, to which she adds three cases from St. Luke's Hospital. "Malignant tumors of the joints, bursae, and tendons may usually be separated into one of two groups, fibrosarcoma or synovial sarcoma." The latter are recognized at operation by the soft cellular quality of the tumor and the usual presence of bluish, cystic spaces with a slightly gelatinous ground substance. Microscopically they present "epithelial-like cells lining tubules, pseudo glands or clefts, outside of which exists a dense felt-work of connective tissue".

Clinically, pain or swelling and tenderness of a joint were the commonest early symptoms. The knee joint was involved nine times; the popliteal region, three times; and the forearm, twice. The prognosis is unfavorable even with early amputation. More than half of the cases occur in patients less than thirty years of age. In all of the author's cases, pulmonary or pleural metastases developed. It is unlikely that radiotherapy will prove effective.

The paper is well illustrated with photomicrographs showing the histological characteristics detailed in the text.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

SYNOVIOMA OF THE HAND. REPORT OF A CASE. William C. Black. *The American Journal of Cancer*, XXVIII, 481, Nov. 1936.

The author reports a synovioma of the thumb in an engineer, thirty-six years of age. Trauma may have played some part in the etiology. At operation the tumor appeared to be encapsulated. Histologically the tumor displayed typical characteristics. There has been no recurrence six months after operation.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

SIGNIFICANCE OF INCREASED PHOSPHATASE ACTIVITY OF BONE AT THE SITE OF OSTEOPLASTIC METASTASES SECONDARY TO CARCINOMA OF THE PROSTATE GLAND. Ethel B. Gutman, Edith E. Sproul, and Alexander B. Gutman. *The American Journal of Cancer*, XXVIII, 485, Nov. 1936.

The authors report a series of phosphatase determinations made by the King and Armstrong method. Determinations were carried out on normal bone, on bone presenting osteoplastic metastases from carcinoma of the prostate, on various other types of diseased bone, as well as both "acid" and "alkaline" phosphatase of normal prostate-gland tissue. They feel that the increased serum-phosphatase activity in various conditions is due to the escape of increased amounts of phosphatase from the areas of bone activity. High bone phosphatase associated with osteoplastic carcinomatous metastases probably causes the new bone formation. The authors believe that certain chemical factors elaborated by some metastatic-tumor cells initiate the osteoplastic type of response, and they raise the question whether the large amounts of "acid" phosphatase in metastases from prostatic carcinoma may have any bearing on the production of "alkaline" phosphatase and the osteoplastic tendencies of prostatic carcinoma metastases.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

LYMPHOSARCOMA OF THE MEDIASTINUM WITH METASTASES TO THE SKELETON. REPORT OF A CASE. William S. Middleton, Ernst A. Pohle, and Gorton Ritchie. *The American Journal of Cancer*, XXVIII, 559, Nov. 1936.

The authors report a large mediastinal lymphosarcoma in a young man of sixteen, with areas of metastatic disease in the liver, the skull, the right humerus, and the right ilium. Radiation therapy brought about extensive necrosis of the primary lesion and relief from pain due to the osseous metastases. In spite of these regressions, the disease ran a rapid course to a fatal termination.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

CLINICALLY DEMONSTRABLE BONE CHANGES IN LEUKEMIA. Charles L. Connor. *The American Journal of Cancer*, XXIX, 20, Jan. 1937.

The author reports two cases of lymphatic leukemia associated with marked bone changes, with roentgenograms. Such cases are uncommon, but may give rise to confusion in diagnosis. The lesions are most frequent in the pelvic bones, the spine, the upper ends of the femora, and the humeri. They occur chiefly in children.

There is a careful review of the literature, leading the author to the conclusion that "the outstanding signs of some leukemias may be pain around the joints, resembling rheumatic arthritis; pain in the long bones as in osteomyelitis; periosteal reactions as in scurvy, periostitis, or leutic periostitis; spontaneous fracture in local osteolytic processes; bulky tumors of single bones; osteolytic lesions, as in myeloma or chloroma".—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

CORRELATION OF PATHOLOGIC AND ROENTGENOLOGIC FINDINGS IN TUBERCULOSIS AND PYOGENIC INFECTIONS OF THE VERTEBRAE. THE FATE OF THE INTERVERTEBRAL DISC. Edward L. Compere and Monroe Garrison. *Annals of Surgery*, CIV, 1038, Dec. 1936.

The vertebral body is richly supplied with nutrient arteries which penetrate the cortex, but do not cross the articular surfaces, while the intervertebral disc, on the other hand, has no blood supply in the adult, nutrition being supplied by the lymphatic system. The fibrocartilaginous annulus blends intimately with the hyaline-cartilage plates above and below, enclosing the nucleus pulposus, the semigelatinous substance of which is incompressible and its narrowing must therefore be obtained by dehydration, extrusion, or destruction.

Vertebral tuberculosis most commonly arises from a hematogenous implant in the spongiosa or compacta of the body, usually in the metaphysis with slow erosion into the cartilage. Such a lesion may be too small to be recognized in the roentgenogram until after the prolapse of the nucleus and destruction of the disc.

In pyogenic infection, the primary focus is in the bone, but the disc is less able to survive the attack, as demonstrated by early roentgenographic evidence. The cartilage plate is rapidly destroyed by the proteolytic enzymes, the nuclear substance is extruded, and the fibrous annulus also undergoes dissolution. The onset is rapid, the duration short, and the symptoms severe. When the infection subsides, there is regeneration of bone, and bony ankylosis occurs more often and more rapidly than in tuberculosis of the spine. Pyogenic infection may spread by direct extension through an intervertebral disc from body to body, but this was not found by the authors in their cases of vertebral tuberculosis. In the latter, spread by extension occurred under the anterior longitudinal ligaments with surface invasion of bone.

Secondary pyogenic infection is a frequent complication, characterized by sinus formation, amyloid disease, and death. The pathological changes may be typical either of tuberculosis or of pyogenic osteomyelitis, or of a combination of the two.

Nine cases are reported, which are excellently illustrated with some forty-two photographic and roentgenographic studies of gross specimens and microscopic sections.—*Norman T. Kirk, M.D., San Francisco, California.*

HYPERPARATHYROIDISM IN SIBLINGS. Leon Goldman and Francis S. Smyth. *Annals of Surgery*, CIV, 971, Dec. 1936.

Primary hyperparathyroidism is a clinical entity, caused by one or more parathyroid adenomata, and has a definite train of clinical, metabolic, and roentgenographic findings, on which the diagnosis is based.

Three important types of parathyroid hyperfunction are recognized:

1. The adenoma, associated with and causing generalized osteitis fibrosa cystica. In the two cases reported this type is characterized by demineralization of the entire skeleton, multiple cyst formation, pathological fracture, hypotonicity of muscle, high

blood calcium and phosphatase and low phosphorus content with a marked negative calcium balance.

2. Hyperplastic type, associated with renal calculi showing high serum calcium, low phosphorus, and no skeletal changes. As reported by Albright, these cases were improved by removal of enlarged hypertrophic parathyroid glands of various sizes.

3. The secondary or compensatory type, in which parathyroidectomy is not indicated, associated with such diseases as arthritis, osteitis deformans, multiple myeloma, metastatic carcinoma, and rickets.

The two cases reported are excellently illustrated, and have been thoroughly studied both preoperatively and postoperatively.—*Norman T. Kirk, M.D., San Francisco, California.*

SUBCHONDRAL TUBERCULOUS SEQUESTRA. Jerome G. Finder. *Annals of Surgery*, CIV, 1080, Dec. 1936.

A six-year review of material seen in Dr. Arthur Steindler's Clinic, a statistical analysis of eighty-six clinically recognized cases, and a histopathologic study of twenty anatomical specimens serve as a basis for the author's conclusions.

The sequestrum is a subchondral tuberculous necrosis appearing roentgenographically as a wedge-shaped area of increased density, not lying "free" as does a pyogenic sequestrum. The density may be caused by deposits of lime salt in tuberculous caseous material, or by lack of absorption of bone in the necrotic focus, while the surrounding living bone becomes porotic and the picture may be confused by hypertrophic arthritis. The diagnosis is simple and absolute only when the focus is separated and extended toward or into the joint. It is often a diagnostic feature of joint tuberculosis.

Bone infection is usually secondary to joint disease, being primary in only 20 per cent. of the cases in this study, invasion occurring at the joint margin where the cartilage is thin. The infarct type of wedge necrosis of bone, due to vascular occlusion, occurs rarely.

The sequestrum when formed can be changed only by: (1) trauma (it is extruded into the joint and ground into fragments or expelled through a sinus); or (2) molecular disintegration. It may be encapsulated in fibrous tissue and remain unchanged indefinitely.

The article is excellently illustrated with some thirty-six histopathological and roentgenographic reproductions.—*Norman T. Kirk, M.D., San Francisco, California.*

A COMPARATIVE RADIOLOGICAL STUDY OF THE BONY CHANGES IN ACHONDROPLASIA, ACROMEGALY, PAGET'S DISEASE, LEONTIASIS OSSEA, CRANIO-CLEIDO-DYSOSTOSIS, DIAPHYSEAL ACALASIA, PERTHES' DISEASE AND FRAGILITAS OSSEA. M. J. S. Pillai. *The Antiseptic*, XXXIII, 741, 1936.

Pillai reports from the Barnard Institute of Radiology at Madras a comparative study of the bone changes in achondroplasia, acromegaly, Paget's disease, leontiasis ossea, cleidocranial dysostosis, diaphyseal acalasia, Perthes' disease, and fragilitas ossea. The report is illustrated by a series of thirty-two x-ray reproductions. The author discusses several problems suggested by his study: notably the part played by the parathyroids in the calcium metabolism of dwarfism and gigantism; the possible superimposition of acromegaly on gigantism; the relation of Paget's disease to dystrophy of the endocrine system; the relation of the endocrine system to osteomalacia and to fragilitas ossea. The author also emphasizes the importance of discovering methods for determining the presence and the exact amount of endocrines and vitamins in the blood stream, as a means of explaining satisfactorily various of the developmental malconditions which he has studied.—*Robert M. Green, M.D., Boston, Massachusetts.*

BRITTLE BONES AND BLUE SCLERAS IN FIVE GENERATIONS. Ralph G. Hills and Samuel McLanahan. *Archives of Internal Medicine*, LIX, 41, Jan. 1937.

The authors report the case of a white girl, aged ten years, who had multiple fractures, dislocation of the hip, and blue sclera. Data were obtained concerning fifty mem-

bers of the patient's family, in twenty-six of whom the main features of the disease were present. Four distinct features of this syndrome are emphasized: fragile bones, blue sclera, a tendency to deafness, and relaxation of the ligaments. Affected subjects tend to be short and slender. The etiology is unknown. The syndrome is best described as a hereditary hypoplasia of the mesenchyma and follows the mendelian law of inheritance, appearing as a dominant character. There is no specific treatment other than protection from injury and treatment of fractures which apparently heal satisfactorily. The fractures tend to occur throughout childhood until puberty is reached. The disease is to be distinguished from a large group of non-hereditary conditions of different etiologies, associated with soft or brittle bones,—for example, osteoporosis, osteomalacia, metastases to bones, hyperparathyroidism.—*Clark W. Heath, M.D., Boston, Massachusetts.*

ACUTE HEMATOGENOUS OSTEOMYELITIS. CLASSIFICATION OF THE CASES OF ACUTE HEMATOGENOUS OSTEOMYELITIS AS DETERMINED BY THERAPEUTIC INDICATIONS; RESULTS OF OPERATIVE TREATMENT. Abraham O. Wilensky. *Archives of Surgery*, XXXIV, 320, Feb. 1937.

Wilensky stresses the fact that acute hematogenous osteomyelitis is not to be treated by routine operative procedures. The condition is a manifestation of a septicaemia and should be treated as a systemic disease. He reports cases in which conservatism was rewarded by satisfactory results. In other instances, in spite of radical drainage of the bony lesion, the blood infection produced fatal results. He also calls attention to the fact that surgical manipulation of an osteomyelitic focus may reawaken a septicaemia that has come under control.—*I. William Nachlas, M.D., Baltimore, Maryland.*

SCIATIC PAIN AND ITS RELIEF BY OPERATIONS ON MUSCLE AND FASCIA. Albert H. Freiberg. *Archives of Surgery*, XXXIV, 337, Feb. 1937.

When the piriformis muscle is under tension it can, through its contiguity with the fibers that make up the sciatic nerve, produce a sciatica. The tension may result from muscle spasm incidental to disease of the sacro-iliac joint (which it bridges) or to disease of the muscle itself. The positive response in the Lasègue test and the symptomatic relief obtained by subperiosteal stripping of the gluteus maximus or by fasciotomy of the fascia lata can be traced to changes in the tension of the piriformis. In addition to this, section of the piriformis, an operation which more directly attacks the cause of the sciatica, has been tried and found successful. Although only three such cases are reported, it is implied that other such operations have been performed, with satisfactory results. It is emphasized that complete studies of the factors causing the muscle spasm are necessary before symptomatic relief may be obtained by myofascial operations which release the piriformis tension.—*I. William Nachlas, M.D., Baltimore, Maryland.*

ROTATION AT THE SHOULDER. A CRITICAL INQUIRY. Lee McGregor. *British Journal of Surgery*, XXIV, 425, Jan. 1937.

On the basis of a careful study of the anatomy and physiology of the shoulder, certain important deductions have been made in regard to the surgery of the region. Many excellent illustrations accompany the text. The author concludes:

1. The shoulder joint is overhung by a closely applied osseofibrous arch.
2. There is room for normal joint movements only beneath this arch and any periarticular swelling means restriction in the motion, with pain.
3. Outward rotation of the humerus is an essential part of the movements of abduction above the horizontal plane.
4. Inward rotation is essential for full flexion.
5. With the arm vertical, no rotation of the humerus is possible.
6. Horizontal abduction in the frontal plane, combined with full external rotation of the arm, is a movement seldom used and, if used, causes discomfort. This position should not be employed in fixing the humerus. The midposition is more comfortable and more satisfactory.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

PATHOLOGICAL FRACTURE OF THE HUMERUS COMPLICATING LATE SECONDARY SYPHILIS. H. Jackson Burrows. *British Journal of Surgery*, XXIV, 452, Jan. 1937.

This is a case report of a patient with acquired syphilis treated actively from its onset. The first knowledge of bone involvement came with a pathological fracture from throwing a skittle ball. Roentgenograms showed extensive bone involvement. Healing occurred in the fracture, and seventeen months later all bones appeared normal by x-ray. The suggestion is made that the extensive bone changes were caused by the treatment rather than by the disease.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

A COMPARISON OF THE RESULTS OF SPINAL FIXATION OPERATIONS AND NON-OPERATIVE TREATMENT IN POTT'S DISEASE IN ADULTS. G. K. McKee. *British Journal of Surgery*, XXIV, 456, Jan. 1937.

The results of 100 cases treated by non-operative means have been compared with fifty cases treated by fixation operations. All lesions were in the thoracic or lumbar regions in patients, sixteen years or older, at the onset of the disease. All patients in the series were in the early stages of the disease and all were treated in the same sanatorium. Patients treated without operation were treated by fixation for eighteen months and in the operated cases fixation was maintained for twelve months.

In the non-operative group, 62 per cent. showed good roentgenographic results; 70 per cent., good clinical results; and 4 per cent., late abscess formation. In the operative group, 38 per cent. showed good roentgenographic results; 32 per cent., good clinical results; and 40 per cent., late abscesses.

The author concludes that spinal operations during the active stage of Pott's disease retard healing and that the only field of operative work in the late stages lies in the correction of deformity.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

LESIONI OSTETRICHE DELLA SPALLA (Birth Lesions of the Shoulder). O. Scaglietti. *La Chirurgia degli Organi di Movimento*, XXII, 183, 1936.

Five different theories concerning the etiology of birth lesions of the shoulder have been found in the literature: (1) lesion of the roots of the brachial plexus during birth; (2) lesion of the scapulohumeral joint during birth; (3) combination of both; (4) lesion during foetal life; and (5) infectious disease during foetal life or during the first days after birth (poliomyelitis or non-specific chronic affection). Of these theories, the first seems to be the most acceptable in the author's opinion.

One hundred and ninety-nine cases from Putti's Clinic are reported. The lesion was unilateral in 186 cases (93.46 per cent.) and bilateral in thirteen cases (6.53 per cent.). Of the 186 unilateral cases, the lesion affected the right shoulder in 125 (62.81 per cent.) and the left in sixty-one (30.65 per cent.). The male sex predominated: there were 110 males (55.27 per cent.) and eighty-nine females (44.72 per cent.).

The fact that the OLA position is the most frequent and that the shoulder of the child is pressed in this position against the pubic bone of the mother is the reason for the preferred occurrence of the lesion on the right side. Three groups of birth lesions are to be distinguished: (1) joint lesions; (2) palsies; and (3) combinations of both. Electrodiagnostic and roentgenographic examinations reveal the type.

Among the articular lesions, the most frequent was a medial and posterior displacement of the head of the humerus. The therapy in these cases was always operative, performed in two steps,—first, Sever's capsulotomy; second, Putti's "derotation" osteotomy. The space between the pectoralis major and deltoid muscles is incised, and the upper portion of the humerus is exposed, care being taken not to injure the circumflex nerve. The second part of the procedure consists of osteotomy of the surgical neck and rotation of the lower fragment in various degrees, depending upon the previous inversion.

The therapy in birth-palsy cases was always conservative,—electrotherapy, massage, and the application of an abduction splint.—*J. Wolf, M.D., Iowa City, Iowa.*

LA CORRECCÍON Y CURA DE LAS DEFORMIDADES DEL RAQUIS Y SU RELACÍON CON EL MENISCO INTERVERTEBRAL (The Correction and Cure of Deformities of the Vertebral Column and Their Relation to the Intervertebral Discs). Edward L. Compere and D. C. Keyes. *Cirugía Ortopédica y Traumatología*, IV, 237, 1936.

The intervertebral disc plays a prominent rôle in the maintenance of the normal function of the vertebral column. Lesions of the vertebral bodies themselves, or of the vertebral discs, or of both, brought about by trauma or disease, are generally followed by deformity of the spine. In the correction of spinal curvatures, either kyphotic or scoliotic, one must bear in mind the part played by the intervertebral discs. If some discs have become thin, due to loss of the content of the nucleus pulposus or to displacement of these nuclear elements, the correction of the spinal deformity cannot be maintained adequately without internal fixation by means of some type of spinal fusion.

The authors have described some typical cases of spinal deformity, including scoliosis, kyphosis due to spinal tuberculosis, compression fractures of the vertebral bodies, and round backs produced by lesions of the vertebral discs. In most of these patients an improvement of the position was achieved by the use of a plaster cast, including the trunk and the legs, with extenders and hinges, at the level of the most prominent point of the deformity.

In old advanced cases, correction was maintained with the aid of internal fixation,—spinal fusion by excision of the articular surfaces, fracture of the spinous processes, and the use of tibial bone grafts.—*Alberto Inclán, M.D., Havana, Cuba.*

NEOPLASMS OF THE SPINAL CORD. A REVIEW OF FORTY-TWO SURGICAL CASES. R. Glen Spurling and Frank H. Mayfield. *Journal of the American Medical Association*, CVII, 924, 1936.

The importance of early diagnosis is emphasized. Early root pain is an important symptom when present, but this occurred in only 50 per cent. of the author's series of forty-two cases. Various sensory disturbances were present in a large percentage of the cases. Sensory levels were established in 55 per cent., but clinical examination alone revealed accurate anatomical location in only a small number of the cases. Motor weakness was the first symptom in 31 per cent. of the cases. Sphincteric disturbances were present in 62 per cent. before operation.

Sympathetic changes consist of color, pilomotor, and sweating disturbances. Of these, sweating is the most important, being diminished below the tumor level in the cord. Disturbances of deep and superficial reflexes below the level of the lesion were almost a constant symptom.

Of principal importance in the study of cerebrospinal fluid are the Queckenstedt test for disturbance of cerebrospinal-fluid dynamics, and an increase in the protein content.

Roentgenographic study without contrast medium may demonstrate conclusively bone changes at the site of the tumor. Properly prepared iodized oil may be used with safety, in quantities not exceeding one cubic centimeter, to locate accurately the block caused by the tumor.

From the standpoint of treatment, all except malignant tumors of the vertebrae are considered surgical. Depending on the type and location of the tumor, treatment may consist of total removal, subtotal removal, or decompression. Those tumors that cannot be completely removed are subjected to intensive irradiation after healing of the surgical wound.

The prognosis as regards operative mortality was approximately 7 per cent. Recovery following surgical removal of benign tumors is remarkably good, but it is impossible to predict at operation the degree of functional recovery by the appearance of the cord.—*W. B. Carrell, M.D., Dallas, Texas.*

INJURIES OF THE HAND. CLINICAL LECTURE AT KANSAS CITY SESSIONS. Sumner L. Koch. *Journal of the American Medical Association*, CVII, 1044, 1936.

In this article the author mentions and then explains five general principles that should govern the treatment of injuries of the hand:

1. No further harm should be done to the injured tissues by the use of antiseptics, hemostats, or the tourniquet improperly applied.

2. Contaminated tissue should not be left in the injured area; this region should be cleansed thoroughly with soap and water, followed by irrigation with normal saline solution. Badly injured tissue is removed by débridement.

3. As far as possible, the leaving of foreign bodies buried in the tissue should be avoided. This applies to unnecessary ligatures, sutures, kangaroo tendon, metal plates, and other mechanical fixation.

4. Every open wound should be closed as soon as it can be done with safety. The author feels that this can be done in most instances where the infected wound is seen early and is thoroughly cleansed mechanically and followed by exact débridement.

5. Finally, the principle of absolute rest should be applied to injured soft parts just the same as it is applied to fractured bones.—*C. J. Connor, M.D., Dallas, Texas.*

BONE GROWTH DISTURBANCE FOLLOWING HEMATOGENOUS ACUTE OSTEOMYELITIS. John C. Wilson and Francis M. McKeever. *Journal of the American Medical Association*, CVII, 1188, 1936.

This paper is based on a statistical study of eighty-five cases of acute osteomyelitis of the long bones and five cases of osteomyelitis of the os calcis.

Of the patients with osteomyelitis of the long bones, 62.35 per cent. had obvious deformity due to disturbance in growth; 21.18 per cent. showed an increase in length, as compared to the well limb, and 21.18 per cent. showed an actual decrease in length. In those cases showing an increase in length in which there was a parallel uninvolved bone, such as in the forearm or in the leg, the uninvolved bone was lengthened correspondingly, so that there was no distortion at the ends and no trouble at the joint. In those showing an actual decrease in length of the involved bones, the parallel bone was not decreased correspondingly, but was at times even increased. In many cases this resulted in a bending of the diseased bone.

Perimetrical hypertrophy is determined by periosteal displacement and is limited by the extent of this displacement. While this perimetrical hypertrophy tends to decrease following healing, it never entirely disappears. It is interesting to note that in bones such as the os calcis, in which the periosteum does not strip easily from the bone, there is no enlargement due to osteomyelitis. Certain deformities are discussed in detail. Coxa valga, resulting from premature closure of the trochanteric epiphysis of the femur, causes an actual lengthening of this bone. Anterior bowing of long bones was noted in five cases and slight degrees of lateral bowing were very frequent. A knock-knee deformity develops either from direct involvement of the epiphysis or from unilateral stimulation either in the tibia or in the femur.

Osteomyelitis of the os calcis is considered separately. It has been found that small abscesses may occur in the body of the bone and recovery may take place without any change in the shape or the consistency of the bone. Since bone grows by accretion rather than at the epiphyseal plate, involvement of the apophysis does not result in shortening or lengthening of the os calcis. When the bone is softened, the muscle pull may alter the shape.

Metatarsal bones and phalanges show great ability to regenerate and to restore normal contour.

The resulting small feet on these involved extremities are difficult to explain, for they occur without prolonged plaster fixation and sometimes they are present when there is only temporary bracing.—*Newton C. Mead, M.D., Dallas, Texas.*

ACUTE HEMATOGENOUS OSTEOMYELITIS. ANALYSIS OF SEVENTY-FIVE CASES. Robert Crawford Robertson. *Journal of the American Medical Association*, CVII, 1193, 1936.

The essential pathological condition in acute hematogenous osteomyelitis is a bloodstream infection, complicated by a local infection of one or more bones. The clinical

trend has been toward early diagnosis and prompt surgical drainage of an increasingly conservative type. Diaphysectomy and tunnelling have been largely replaced by drilling and removal of a cortical window at the earliest possible moment. Early drainage is advocated on the grounds that the infection occurs within the medulla, usually in the metaphyseal region from which it follows the lines of least resistance, resulting in extensive necrosis and subsequent sequestration.

Analysis of the series disclosed a preponderance of males; most of the patients were between five and fifteen years of age; and there was a relatively small proportion of negroes. Predisposing trauma was not found in 62.6 per cent. of the cases. The distal end of the femur or the proximal end of the tibia was involved in 45.3 per cent. Staphylococcus alone was found in 69.3 per cent. of the wounds and in 24 per cent of the blood cultures. Pain on local bone pressure was present in 63.1 per cent. of the cases not showing sequestration by roentgenographic examination, but in only 4.1 per cent. of the cases that demonstrated sequestration. Fluctuation was found in 31.5 per cent. of the patients, half of whom were under two years of age. The average duration of twenty-two days in the older children was one-third greater, with more deaths, than in children under two years of age.

The type of drainage employed consisted of draining of soft-tissue abscesses, without opening into underlying bone; subperiosteal abscesses were incised, and the underlying cortical window was removed. Postoperative treatment in all cases was by the Orr method, or by a slight modification of this method.

Of the cases without sequestration, 68.4 per cent. were complicated by joint involvement; whereas, of the cases with sequestration, the joint was involved in only 2.3 per cent. Metastatic lesions were most common in cases with sequestration; pathological fracture occurred only twice. Adjacent suppurative arthritis from bone involvement occurred in 24 per cent. of the cases, the hip being involved in 55.5 per cent. Diagnostic aspiration was done routinely.

The mortality rate in the cases with one or more positive blood cultures was 28.6 per cent., death occurring in one week in three-fourths of these cases. Blood cultures in these cases contained staphylococci alone or in combination with streptococci in 75 per cent of the cases.

From this study, the author draws the following conclusions:

1. In children under two years of age, the clinical course of the disease varies widely from that in adults.
2. The American negro is relatively immune to the disease.
3. Acute hematogenous osteomyelitis must be considered when pyrexia and localized pain on bone pressure coexist in the absence of obvious cause.
4. The majority of the best results were obtained by drainage of the bone within one week following onset. The mortality rate was highest in cases in which drainage was instituted within this period.
5. The pathological changes present, while usually directly proportionate to the duration of symptoms, are influenced by many factors.
6. Acute pyogenic suppurative arthritis should be considered to be osteomyelitis of an adjacent bone until proved otherwise.
7. Clinically, joints are more resistant to infection than bone and apparently possess bactericidal properties.—*P. C. Carson, M.D., Dallas, Texas.*

BRODIE'S ABSCESS OF RADIUS, DUE TO TYPHOID. REPORT OF A CASE. William B. Marbury and Henry L. Peckham. *Journal of the American Medical Association*, CVII, 1284, 1936.

Typhoid of the bones is one of the unusual types of inflammatory bone disease. According to Murphy, it occurs in one out of every 233 cases. The bones usually involved, in order of frequency, are: ribs, tibia, vertebrae, femur, clavicle, hand, and radius. The radius is involved only once in 106 cases of osteomyelitis due to typhoid. The abscess may occur in bone from five to fifteen years after infection with typhoid bacillus.

Brodie's abscess is a "bone cavity filled with serum or pus, lined by a fibrous membrane, with surrounding sclerosed bone and a tendency toward obliteration of the adjacent medullary cavity". This abscess usually occurs near the center of the metaphysis, giving rise to symptoms of boring pain referred to the center of the bone and aggravated by use. The symptoms are marked tenderness on pressure or percussion, hydrops of the adjacent joints, and local enlargement of the bone and of the superficial veins; constitutional symptoms are few. Diagnosis is by roentgenogram and by the presence of the symptoms enumerated. Treatment consists of immediate and adequate drainage. The prognosis is good if drainage is adequate.

The authors report the case of a girl, fifteen years of age, with pain in the left forearm for two months, followed by swelling and redness. She had had typhoid at five years of age. Examination revealed a swollen, tender left forearm to the radial side, with redness and elevation of surface temperature. Roentgenographic examination disclosed an oval, slightly irregular, translucent area within the shaft of the radius. The white blood count was 10,100, with 61 per cent. polymorphonuclear leukocytes; the Widal test was positive in dilutions ranging from 1 to 20 to as high as 1 to 320. At operation, ten days after admission, the abscess cavity was opened, and the smear and culture disclosed typhoid bacillus. There were no symptoms after four months.—*P. C. Carson, M.D., Dallas, Texas.*

FRACTURE OF THE NECK OF THE FEMUR. EVALUATION OF THE VARIOUS METHODS ADVANCED FOR TREATMENT. Paul B. Magnuson. *Journal of the American Medical Association*, CVII, 1439, 1936.

The anatomy of the femoral neck is described thoroughly and comparisons are made between the weight-bearing lines in young persons and in elderly persons, in whom they may be almost completely absent.

The lack of control of the proximal fragment is often a cause of trouble in these fractures. There is no blood clot formed because the hemorrhage is mixed with synovial fluid and remains fluid. The capsule is shortened because of the distention, and this may interfere with reduction. The blood supply to the neck is often poor.

An important part of the blood supply is from the visceral capsule and it seems logical to believe that injuries tearing this capsule would be slower to heal than others. The exact angle of fracture is, therefore, important and records should be made to show which types produce the most cases of non-union.

The ligaments of the hip joints are relaxed in flexion and tightened in extension. If the fragments are not in immediate contact, extension would further misplace them.

The author believes that one of the important reasons for the fact that extracapsular fractures heal better than intracapsular ones is that the proximal fragment is not entirely out of control in the former.

Anteroposterior roentgenograms are inadequate in determining the approximation of the fragments, and a great many lateral views are also inadequate. Accurate reposition of fragments is necessary to promote union. What may seem to be good position may actually allow contact between a small portion of the fractured surfaces, the rest of which are in contact only with bloody synovial fluid.

In transverse fractures internal rotation tightens the posterior capsule, so that it acts as a soft splint, and the fracture surfaces are brought together. Extension further increases this contact. If distention of the capsule prevents end-to-end contact, these manoeuvers angulate the fragments. If the fracture line is oblique and follows the general direction of the weight-bearing line, internal rotation and extension will push the fragments past each other. Diagrams are presented to show the various angles of fracture and the results obtained by external and internal rotation. Other diagrams show the effect of abduction.

The author describes a fracture near the head in which the head is in valgus position, allowing a good weight-bearing line. This type has never failed to unite in his experience.

As to the choice of methods of treatment, these depend on whether or not reposition

of the fragments can be accomplished and reduction maintained, as well as on the patient's physical and economic circumstances. The Anderson and the Jones splints apparently hold fragments in good position, but actually they may not, for it is impossible to get good lateral roentgenograms once these splints are applied. Their advantage over the Whitman method is in the simplification of the nursing and the ability of the patient to move about.

Internal fixation, blind or open, is discussed. The Smith-Petersen three-flanged nail, the visual reduction of Scuderi and Callahan with Cubbins, the bone graft of Albee and others, and the three-pin method of Moore, all are discussed. In all methods accurate anatomical reposition is necessary for good results.

Another open method which is used by the author is described and advocated for use in fresh fractures. The head is hollowed out in the form of a parabola; the trochanter is cut off obliquely from above downward and outward; and the end of the neck is fitted into the head. The trochanter is reattached below its former location. This results in a good weight-bearing line, and union has always followed this operation in the author's experience. He also uses it in ununited fractures and it has resulted in revascularizing necrosing femoral heads. The method does not necessitate immobilization of the hip, the knee, or the ankle.—*W. B. Carrell, M.D., Dallas, Texas.*

TUBERCULOSIS OF THE HIP IN CHILDREN. Joseph S. Barr. *Journal of the American Medical Association*, CVII, 1517, 1936.

The article is based on 106 consecutive patients admitted with a diagnosis of tuberculosis of the hip. Fifteen per cent. of these diagnoses later proved incorrect, so that the author considers only the ninety definite cases of tuberculosis.

Until 1920, the author's treatment was expectant, ambulatory if possible. Surgical evacuation of abscesses was frequent and was followed by ordinary technique in dressings. Plaster spicas were used for long periods. From 1920 to 1930, heliotherapy, according to the method of Rollier, was used. The patient was placed on a frame in skin traction. No surgery was done. From 1930 until the present time, arthrodesis has been used as the supplementary treatment.

The mortality of tuberculosis of the hip is due to two main causes,—tuberculous meningitis and deep-seated secondary pyogenic infection of the sinuses. Tuberculous meningitis caused 47 per cent. of the deaths. The method of treatment probably does not effect this very much, although arthrodesis might increase the proportion of meningitic deaths. In 40 per cent. of the cases with a fatal outcome, death was due to a deep-seated pyogenic infection of the sinuses. The immediate cause of death was amyloid disease. This is preventable if dressings are carefully done and secondary infection is guarded against. The author allows cold abscesses to rupture spontaneously, but the skin is carefully cleansed and covered with a sterile dressing before rupture takes place. When infection is already present, free dependent drainage is obtained.

The author does not recommend biopsy in early cases, for this often results in an infected sinus. Instead, he believes that aspiration is the best method for obtaining diagnostic material.

Tuberculosis of the hip runs a variable course and the amount of destruction of bone varies. Abscesses were noted in over one-half of the cases. All cases in which there were no complications had reached a quiescent state at the end of four years, most of them after two years. This quiescent state does not represent a cure.

Heliotherapy, as used by Rollier, did not seem to be very effective in the author's cases. These patients showed no more improvement roentgenographically and no better blood picture or clinical appearance than did those not receiving this treatment. The author believes that a moderate amount of sun is good for patients, and that complete rest, local and general, as in pulmonary tuberculosis, is favorable.

Fusion should not be done until the quiescent stage is reached, for in the active stage there is a higher mortality rate and not more than 50 per cent. of the hips are successfully fused. Moreover, even if the fusion is good, the natural process must still be followed.

Attempts to restore active function to hips in which the disease has been arrested are disappointing, for such procedures activate the infection. The disease is more likely to remain arrested in fused hips.

The use of the intra-articular arthrodesis is condemned. The author does not use the massive graft in children, for he feels that it is less likely to fuse and that there is difficulty in maintaining its position while the wound is being closed and the plaster is being applied. The author's technique is briefly as follows:

Through a Smith-Petersen incision, the capsule is cut longitudinally and dissected away. No attempt is made to remove all of the diseased tissue, but visible cartilage is removed from the acetabulum and the femoral head. A cortical flap is raised posteriorly, laterally, and anteriorly from the femoral neck and the greater trochanters. From three to four grafts are then removed from the wing of the ilium and slid down to surround the neck, the lower ends being wedged firmly beneath the flaps at the greater trochanter. The upper ends are still in contact with the cancellous bone of the ilium. A flap of the ilium, just above the acetabulum, is raised and laid across the grafts. No plaster cast is applied. Instead, a firm ace-bandage spica is applied to prevent a hematoma. The child is then placed on a slightly hyperextended Bradford frame with from five to eight pounds of weight on a canvas-stocking extension.

The best position for the fused hip is at from 20 to 25 degrees of flexion, from 0 to 15 degrees of abduction, and from 0 to 5 degrees of external rotation. However, to obtain this final result the author places the limb in full extension and in from 15 to 20 degrees of abduction.

Of twenty-three consecutive cases in which this operation was employed, solid fusion was obtained in 86 per cent. There were three failures, due to destruction of the graft by the tuberculous process. In no case was there shock or sepsis.—*Newton C. Mead, M.D., Dallas, Texas.*

THE OPERATIVE VERSUS THE MANIPULATIVE TREATMENT OF SLIPPED FEMORAL EPIPHYSIS. WITH A DESCRIPTION OF A CURATIVE OPERATION. Samuel Kleinberg and Joseph Buchman. *Journal of the American Medical Association*, CVII, 1545, 1936.

This article discusses the anatomy and the physiology of the slipped epiphysis as compared to the normal epiphysis and from certain deductions suggests reasons why operative treatment is preferable in all types of cases. It also discusses the pathology in the disc.

The conclusion is that, in cases other than the acute cases of slipped epiphysis, reduction and accurate reposition are impossible by manipulation. Even in the acute cases the author states that the end results are poor because of the trauma done to the head of the femur during manipulation and the impossibility of reestablishing a normal circulation to the head through the diseased epiphyseal disc. He, therefore, recommends operative treatment in all cases.

The operative technique consists in the removal of the deformed disc and the nailing together of the accurately repositioned neck and head by the use of an ivory peg, which is introduced through the fovea capitis femoris after the complete removal of the head from the acetabulum, followed by reduction of the head.

The limb is then placed in 30 degrees of abduction and is immobilized in a plaster-of-Paris cast for four weeks.—*C. J. Connor, M.D., Dallas, Texas.*

FRACTURE OF THE NECK OF THE FEMUR IN CHILDREN. Joseph I. Mitchell. *Journal of the American Medical Association*, CVII, 1603, 1936.

Fracture of the neck of the femur is less common in children than in adults past middle age. The method of treatment usually employed in the past for all age groups has been immobilization of the hip in abduction; however, Böhler recommended the use of continuous traction for three months. The types of fractures encountered are: (1) epiphyseal separation; (2) transcervical fracture; (3) cervicotrochanteric fracture. In this series of ten cases, seven were cervicotrochanteric fractures, two were transcervical

fractures, and one was an epiphyseal separation. Four patients were boys and six were girls, ranging in age from four to fifteen years. The cause of fracture in each case was trauma. Bony union occurred promptly in nine cases; good anatomical position, necessary for good function, was found in only three cases, and in four cases the fragments had united in malposition. There was non-union in one case.

Treatment of recent fractures consisted of reduction and immobilization. Whitman's position was used in two cases; in one case a good result was obtained, and in the other two subsequent operations were necessary to correct the coxa vara. In a third case a good result was achieved by the Hoke-Martin apparatus incorporated in plaster. Therefore, all recent fractures of the neck of the femur in children should be treated by continuous traction for eight weeks and the limb should be protected from full weight-bearing for three months, even after the patient is ambulatory. In malunited fractures, the coxa-vara deformity is corrected and the femur lengthened by oblique osteotomy, followed by skeletal traction.—*W. B. Carrell, M.D., Dallas, Texas.*

LATE INFECTION FOLLOWING THE USE OF PINS AND WIRES IN BONES. S. L. Haas. *Journal of the American Medical Association*, CVII, 1607, 1936.

The wide-spread use of pins and wires in obtaining reduction of fractures has not been accompanied by proper recognition of the dangers and sequelae following their use. Many fractures which could be reduced by other means are subjected to unnecessary risks. When a wire is inserted under strict aseptic technique, there is still a portal of entry. There is also an opening which serves as a drain. Granulation forms and acts as a barrier to the infection. For this reason pins and wires should not be allowed to move, for this injures the granulation barrier. After removal of the pin, the soft parts heal more slowly than the bone and this results in a sealed off, non-collapsible tube in the bone, an ideal spot for incubation of latent bacteria. This infrequently happens, but small sinuses and sequestration do occur too frequently.

In a series of seventy cases of leg-lengthening, late infection developed in three, necessitating opening and curettage approximately two years after the pins were removed. This operation was followed by cure of the late infection. The cases were all in children and in each case trauma appeared to be an exciting factor in stirring up the late infection. In all of these cases the cancellous bone of the metaphysis was the site of the infection. A factor favoring late infection may be the force necessary in lengthening operations. When stainless-steel wire is used, there is less local disturbance. At the time of operation the infection was found to be of low grade, the marrow being replaced by fibrous tissue similar to that of osteitis fibrosa.

In extremities which have been treated with pins or wires a subsequent operation may be followed by infection.—*W. B. Carrell, M.D., Dallas, Texas.*

RESULTS OBTAINED BY SUBCUTANEOUS PINNING OF FRACTURES THROUGH NECK OF FEMUR. Avery Rowlette, J. R. Haslem, R. B. Siegert, H. D. Morris, and J. Albert Key. *Journal of the American Medical Association*, CVII, 1610, 1936.

Twenty cubic centimeters of one-per-cent. procaine hydrochloride is injected into the hip joint. Manipulation is then carried out by flexing the thigh to 90 degrees, in a slightly adducted and externally rotated position. Traction is then applied directly upward in the long axis of the femur, while an assistant pulls the upper thigh outward and downward. While traction is maintained, the thigh is circumducted outward and downward and internally rotated. With the heel supported, if it remains in internal rotation, the reduction is satisfactory. Anteroposterior and lateral roentgenograms are made. While the films are being developed, the lateral surface of the thigh below the trochanter is anaesthetized. A stab wound is made in the skin about three inches below the tip of the greater trochanter, and a stainless-steel pin (one-eighth of an inch in diameter, eight inches long, and threaded for a distance of one inch) is inserted down to the femur. The pin is directed in a horizontal plane and upward at an inclination approximating that of the neck of the femur. The pin is drilled into the bone about three inches. Another

roentgenogram is taken and a second pin is inserted, a quarter of an inch above and parallel to the first pin. After this, adjustment of the first pin may be made.

Forty-six cases have been treated by this method in the past eighteen months, only thirty of which have been under careful observation for more than eight months. Of these, six patients have died; one has non-union; three still have pins in and fragments in good position; and thirteen have firm bony union. Among the sixteen cases not yet under observation for eight months, there have been three deaths and two cases of apparent non-union. The failures may be attributed to: (1) poor general condition of the patient; (2) poor reduction; (3) faulty insertion of the pins; (4) failure of the pins to remain in position; and (5) bending of the pins.—*P. C. Carson, M.D., Dallas, Texas.*

THE TREATMENT OF PRIMARY MALIGNANT CHANGES OF THE BONE BY RADICAL RESECTION WITH BONE GRAFT REPLACEMENT. Fred H. Albee. *Journal of the American Medical Association*, CVII, 1693, 1936.

The treatment of malignant growths of bone, especially sarcoma, is extremely unsatisfactory. Metastases develop in spite of the most radical procedures. The author describes a method of eradicating the malignant tumor, but still preserving the usefulness of the extremity. The tumor is resected radically, followed by plastic bone-graft replacement. The author reports thirteen cases in which this method was used.

In three cases in the shoulder region, the upper end of the humerus was replaced by the upper end of the fibula. The diagnoses were osteosarcoma, malignant giant-cell sarcoma, and sclerosing osteogenic sarcoma. The first two patients recovered fully, one of them being alive seventeen years following the operation; the third died of spinal-cord metastases.

Seven cases in the knee region are presented. The diagnoses in these cases were osteogenic sarcoma (two cases), chondrosarcoma (two cases), osteochondrosarcoma, malignant giant-cell sarcoma, and round-cell sarcoma. In one of these cases, that of the highly malignant osteochondrosarcoma, it was possible to save the joint. In each of these cases a cortical graft from the tibia was used.

There were three cases in the tibia, the diagnoses being osteogenic sarcoma, malignant giant-cell sarcoma, and Paget's disease becoming malignant osteogenic sarcoma.

The author concludes that it is possible, in selected cases at least, to preserve a useful extremity in treating bone malignancy. In all of the cases presented, there was no example of local recurrence, although metastases resulting in death occurred in three cases. Dr. Albee believes the method is always indicated in cases of so called benign giant-cell tumors where amputation is indicated. The hematoma which forms about the bone graft may become infected and it is a serious complication. It resulted in the amputation of the extremity in one case in the series.

As far as recurrence is concerned, the method seems to be as safe as amputation.—*Newton C. Mead, M.D., Dallas, Texas.*

GIANT CELL BONE TUMOR. FURTHER OBSERVATIONS ON TREATMENT. Carleton B. Peirce and Isadore Lampe. *Journal of the American Medical Association*, CVII, 1867, 1936.

This is a statistical study based on forty cases, twenty-five of which were diagnosed at autopsy and the rest by clinical and roentgenographic findings. The cases are divided into five groups, a separate table being presented for each group. The groups are as follows: (1) untreated cases; (2) those treated by preoperative x-ray, surgery, and postoperative x-ray; (3) those treated by surgery and postoperative x-ray; (4) those treated by surgery only; and (5) those treated by radiation only.

The authors' conclusions are that the lack of uniformity in the treatment of giant-cell tumors by combined surgery and x-ray defeats any attempt at satisfactory comparative analysis.

Preoperative radiation has been permitted little opportunity for effect and has been urged on radiologists largely in those cases which are unfavorable at the outset.

Secondary infection, subsequent to primary surgical intervention or biopsy, offers definite obstruction to improvement by irradiation.

Adequate curettage has induced good functional results in anatomically accessible areas.

Either adequate treatment with x-rays or adequate surgical intervention offers as much as a combination of the two.

Conservative treatment with x-rays will afford symptomatic relief and induce anatomical repair.—*Newton C. Mead, M.D., Dallas, Texas.*

TUBERCULOSIS OF THE SPINE AND SCOLIOSIS. AN IMPROVED TECHNIC FOR ARTHRODESIS OF THE VERTEBRAL JOINTS. Charles S. Young. *Journal of the American Medical Association*, CVII, 2035, 1936.

Arthrodesis of the spinal column in scoliosis and tuberculosis of the spine has presented the problem, the solution of which calls for an operation that will apply to all regions of the spinal column, that will be reasonably certain of arthrodesis without development of pseudarthroses, and that will have a minimum amount of surgical shock. The widely used operations are those of Hibbs and Albee. The Hibbs operation is intra-articular, but it has the disadvantage of causing undue trauma to the central nervous system. Also, in scoliosis, with severe rotation, it is not technically possible to remove cartilage from the deep side. The Albee operation is extra-articular and presents a difficulty due to lack of uniformity in the spinous processes. The sacral processes are too rudimentary, and the thoracic spinous processes, when bisected, present very narrow and thin surfaces for the reception of bone transplant.

The author describes an operation which he has been using in tuberculous diseases of the spinal column. The skin and superficial fascia are reflected until the supraspinous ligaments are exposed and divided in their midline longitudinally and are reflected laterally with the muscles, which are separated subperiosteally from the spinous processes and the laminae. Care must be taken to remove every particle of these ligaments from the laminae and the spinous processes. Two flexible bone grafts are next obtained from the tibia. The graft is fitted so that its raw surface is in perfect contact with each lamina and base of the spinous process. The grafts are held in position by suturing the periosteum to the spinous process. Postoperative immobilization is maintained by means of a plaster-of-Paris body jacket. In young children, the shells are made and dried before operation. The older children are placed on Bradford frames, unless severe kyphosis is present, until after the sutures have been removed; then plaster-of-Paris jackets are applied. The patient should remain recumbent for from three to six months. On removal of the plaster-of-Paris jacket, a back brace is worn for from six to nine months.

In the thoracic region, in cases of severe kyphosis, the spinous processes may be excised to decrease the deformity.

In treating scoliosis, the procedure is the same except that in cases of marked rotation one side may be done and a wide graft used. Postoperative treatment consists of head and pelvic traction or a turnbuckle jacket for from four to six months.—*W. B. Carrell, M.D., Dallas, Texas.*

CLUB-FOOT AND ITS TREATMENT. A. Wilfrid Adams. *The Medical Press and Circular*, CXCIII, 348, 1936.

The author stresses the necessity of seeing and treating these cases early to get the maximum correction without stiffness. Inversion, especially of the heel, adduction, and cavus are the main elements of the deformity. Correction should be attempted as soon after birth as can conveniently be arranged.

The following method of treatment will give the potential cripple a foot of well-nigh perfect form with full function.

The infant is anaesthetized and firm pressure is made over the heel to correct the heel varus. Next, the forefoot adduction is corrected by manual pressure and plaster is applied. The author stresses the importance of extending the plaster to the tip of the

toes; the toe opening should be narrow to prevent overlapping of the digits, due to the inward pressure of the cast.

In two weeks the plaster is removed and the same procedure is repeated, until in about eight weeks the foot remains in its overcorrected position.

Correction of the equinus is then begun by a manipulative procedure every three weeks until the dorsum of the foot touches the front of the tibia.

The completion of this series of manipulative procedures concludes the first stage of treatment.

The preservation of this correction is maintained by the use of a light wooden sole plate fixed to the foot and leg by elastoplast straps.

After twelve months, the retentive appliance is removed and walking is permitted. Strapping may be reapplied if relapse threatens.

In late stages, manipulative correction with transplantation of the tibialis anterior to the fifth metatarsal is a good procedure, or a modified Steindler operation may be used. In old cases or in adults, the writer uses osteotomy through the forefoot and tarsal bones, or Syme's amputation.—*Herbert E. Hipps, M.D., Marlin, Texas.*

THE PROBLEM OF THE CHRONIC ARTHRITIC. P. F. Ashton. *The Medical Press and Circular*, CXCIII, 485, 1936.

There is no excuse for the pathetic case of the hopelessly crippled arthritic if the patient is seen early enough and a rational method of treatment is instituted.

Geography, climate, and diet play no part in the etiology of arthritis except in the cases of undernourished and very obese individuals. With the two exceptions just mentioned, arthritics may eat what they like.

Arthritis may be broadly divided into two distinct groups: polyarthritis and osteoarthritis.

There are two pathognomonic symptoms in polyarthritis: (1) stiffness in the joints on waking in the morning or after a rest period during the day; (2) the patient may complain of dropping things if the early arthritic process is in the upper extremity, or of his knees giving away, if in the lower extremity. These symptoms appear before joint soreness, swelling, etc. occur.

There are three main varieties of polyarthritis, but the symptoms described are common to all types. These varieties are grouped according to age and are as follows: (1) adult, (2) menopausal, and (3) senile.

In the treatment of polyarthritis rest is by far the prime essential for a possible cure of this disease. This is very important, as most patients have the idea that rest makes the joints stiff, whereas the converse is true. Massage, carefully given, is of value. Medication may consist of salicylates, or of thyroid extract if the patient is obese, and in some cases acetylcholine is prescribed because of its selective action on the sympathetic nervous system and its subsequent warming up of cold extremities.

Osteo-arthritis is nearly always traumatic in origin and is simply a senile decadence or wearing out of the involved joints. The symptoms vary, but frequently the pain is referred down the arm or leg below the joint; nerve pain from the spine is also encountered.

Treatment is rest of the involved joint, and again this is of prime importance. Physical therapy is of definite value here. Diathermy through the involved joint gives considerable and quick relief from pain, but it should not be given daily. Two or three times per week is better to allow for full tissue response after each treatment. Massage is of no value in these cases.—*Herbert E. Hipps, M.D., Marlin, Texas.*

BEITRÄGE ZUR KLINIK UND THERAPIE UNSPEZIFISCHER WIRBELERKRANKUNGEN (Some Clinical and Therapeutic Aspects of Non-Specific Affections of the Vertebrae). F. Raszeja. *Mitteilungen aus den Grenzgebieten der Medizin und Chirurgie*, XLIV, 401, 1936.

The author divides the non-specific affections of the vertebrae into three categories:

1. The first group comprises the acute and subacute suppurative inflammatory conditions of the vertebrae (spondylitis staphylomycotica and streptomycotica). The treatment is purely surgical and must ensue as soon as the diagnosis is established. Abscesses are incised; aspirations and irrigations are insufficient and are even injurious. The incision should be extended to the site of infection to permit curettage of the affected portions of bone and to remove any sequestra which form for the most part in the vertebral arches. When the vertebral bodies are affected, costotransversectomy and lumbovertebrotomy are to be considered. Paralyses definitely indicate laminectomy. Plaster-bed immobilization guards against gibbus formation. A plaster or steel corset must be worn during convalescence.

2. In the second group, the author includes chronic vertebral osteomyelitis, infectious spondylitis, and the more infrequent vertebral affections which occur in the course of various infectious diseases (spondylitis typhosa, paratyphosa B). Four cases are discussed in detail. The treatment of the disease forms belonging to this group is fundamentally surgical, although too radical a procedure is not indicated and is limited in the first place to the incision of abscesses. There is no indication for the invasion of the site of the infection, which is usually found in the vertebral body. Paralyses present no indication for laminectomy here; they usually regress spontaneously, and more rapidly following x-ray therapy. In addition to x-ray therapy, which seems to be applied more frequently than before in cases of paraesthesia and root symptoms, blood transfusion has been used with success; convalescent survivors of acute osteomyelitis are preferred as donors. Results obtained with polyvalent vaccination or autovaccination were not striking.

3. In the third group, the treatment of spondylarthritis ankylopoetica is described, which the author regards as a rheumatic or rheumatic-infectious affection, and he distinguishes three clinical stages. Rather large doses of pyramidon are administered and light thermotherapy is chosen in the initial stage. In the fully developed stage, stimulation therapy and hyperthermia of the tissues (diathermy, mud packs, and baths) come into consideration. Hydrotherapy, massage, and gymnastic exercises are indicated during the painless-interval stage. Immobilization in plaster beds or corsets is injurious. Movement is necessary in all stages. Painful intercostal neuralgia is alleviated by intercostal anaesthesia and with greater success by paravertebral anaesthesia according to Laewen. Rabl's acidification with ammonium chloride has not been successful. Parathyroidectomy was attempted in three cases; in two cases, the results were fairly good. The author regards this operation to be indicated in all cases of high hypercalcaemia and in younger individuals in whom the condition has not resulted in any marked bone changes.—*O. Theodore Roberg, Jr., M.D., Chicago, Illinois.*

MENISCUSGANGLIEN UND UNFALL (Cysts of the Semilunar Cartilage and Trauma). H. W. Ott. *Monatsschrift für Unfallheilkunde und Versicherungsmedizin*, XLIII, 618, 1936.

Cysts of the semilunar cartilage are probably far more prevalent than the previous reports would indicate. Failure to recognize them is responsible for the small numbers reported in the literature. In most of the cases hitherto described, trauma was supposed to be the important etiological factor. Ott, however, is of the belief that there is an anlage which is responsible for this condition. He reports five cases.—*I. William Nachlas, M.D., Baltimore, Maryland.*

TRAITEMENT DE CERTAINES FRACTURES ARTICULAIRES (Treatment of Certain Articular Fractures). René Leriche et Fritz Froehlich. *La Presse Médicale*, XLIV, 1666, 1936.

In certain types of articular fractures, where there is no displacement, or where exact reduction is not necessary, periarticular infiltration of the ligaments and intra-articular injections of novocain, to block the vasomotor phenomena, which lead to second-

ary arthritis, are indicated. The possibility of resuming active motion immediately permits cure in the minimum of time, with the maximum of function.

The authors report a case of comminuted fracture of the elbow, another of fracture of the head of the radius, and a third of transverse fracture of the patella, in which daily injections of novocain were given. As long as there was pain which prevented active mobilization, twenty cubic centimeters of 1-per-cent. novocain was injected into the periarticular ligaments daily, until a free range of painless motion was possible.

The results in these cases were extremely satisfactory. In only one case was the disability prolonged to three months.—*Henry Milch, M.D., New York, N. Y.*

L'HÉMATOME DU QUADRICEPS CRURAL (Hematoma of the Femoral Quadriceps). Paul Durand. *La Presse Médicale*, XLIV, 1736, 1936.

A teamster was kicked on the anterior surface of the thigh and thrown to the ground. Examination disclosed tenderness, inability to walk, no fluctuation, and inability to flex the leg upon the thigh. This loss of flexion is particularly important, since it indicates the characteristic of muscle injuries,—resistance to lengthening of the injured muscle fibers.

The author advised treatment by aspiration and subsequent injection of two cubic centimeters of Calot's solution.—*Henry Milch, M.D., New York, N. Y.*

QUELLE INFLUENCE UNE THROMBOSE LIMITÉE EXERCE-T-ELLE SUR LES ARTÈRES EN AVAL? (What Influence Does a Limited Thrombosis Exert on the Peripheral Portions of the Artery?) R. Fontaine, E. Lucinesco, R. Schattner, et A. Oswald. *La Presse Médicale*, XLIV, 1860, 1936.

As a result of studies of the effects of arteriectomy and of limited thrombosis of an artery on the peripheral portions of the artery, the authors came to the conclusion that the arteriectomized animals showed a richer peripheral vascularization, with fewer cases of trophic disturbance, ulceration, or gangrene than did those in whom segmental thrombosis had been accomplished. In studying nineteen experimental animals they noted that the arteriectomized animals showed absence of the secondary arteritis, which was associated with thrombosis. This is in accord with the findings of Leriche and is probably to be attributed to the vasodilatation which follows arteriectomy. This is consequently in accord with Leriche, who suggests arteriectomy in cases of limited thrombosis.—*Henry Milch, M.D., New York, N. Y.*

POLYRADICULON NÉVRITES (Polyradicular Neuritis). G. de Morsier et J. Steinmann. *La Presse Médicale*, XLIV, 1890, 1936.

The authors report two cases of the syndrome described by Guillain, Barré, and Strohl in 1916. This condition is characterized by paraesthesia, muscle weakness, loss of tendon reflex with persistence of the superficial reflexes, hyposensitiveness of the lower extremities, loss of sphincteric control, and most particularly a hyperalbuminosis, without pleocytosis. One of these patients recovered and the other died. In this latter case autopsy disclosed no evidence of any spinal-cord lesion, but there was a marked perivascular infiltration about the nerves, as well as definite evidence of inflammation of the sheath of Schwann. In the milder cases, which involve the lumbar nerves, recovery occurs. Where the lesion is situated higher and involves the cranial nerves, as in the second case reported, death may occur.—*Henry Milch, M.D., New York, N. Y.*

TRAITEMENT AMBULATOIRE DES FRACTURES DU CALCANÉUM (Ambulatory Treatment of Fractures of the Calcaneum). Philippe Graffin. *La Presse Médicale*, XLV, 61, Jan. 13, 1937.

Six cases of fracture of the os calcis are reported in which immediate ambulatory treatment was undertaken. The technique is as follows. Stockinet is drawn over the leg from the toes to below the tibial condyle. A pad of cotton, four centimeters thick, is now placed over the heel, extending from the upper surface of the ankle joint posteriorly

along the back of the heel to its plantar surface as far forward as the calcaneocuboid joint. Another piece of stockinet is placed over this to hold the cotton in place, and plaster-of-Paris is applied from the toes to below the knee. The plaster is made particularly strong, to permit walking, and is flattened by means of a board. As the patient walks, the os calcis tends to be pushed down into the space between the stockinet and the plaster.

Of the six cases, five showed excellent results within a period of two months, regardless of the nature of the fracture. The author concludes that in this way the severe symptoms of post-traumatic arthritis and the long disability may be avoided.—*Henry Milch, M.D., New York, N. Y.*

FRACTURES IN THE REGION OF THE SHOULDER-JOINT. R. Watson Jones. *Proceedings of the Royal Society of Medicine*, XXIX, Section of Orthopaedics, 20, 1936.

The author reviews 571 injuries to the upper end of the humerus treated in the fracture clinics of the Liverpool Royal Infirmary during the five-year period from 1929 to 1934. He discusses the treatment which these cases received according to the following classification:

1. Fracture of the greater tuberosity;
2. Dislocation of the shoulder joint;
3. Fracture of the neck of the humerus;
4. Fracture-dislocation of the shoulder.

1. If the bone is fractured by direct contusion, there is little displacement. If the fracture is associated with great traction by the supraspinatus, there is usually displacement. Recent cases never need operative treatment.

2. Myositis ossificans is encouraged if passive movement is done, whereas if only active motion is allowed there is little evidence of myositis ossificans. The incidence of nerve injury is great,—thirty-four nerve injuries in 231 cases.

3. There are three types of fracture: contusion crack without displacement, adduction fracture, and abduction fracture. The adduction fracture is usually impacted. The abduction fracture is or is not impacted.

4. This type may be impacted or unimpacted. Reduction may be possible without incision. In certain cases, even with reduction of the head, an aseptic necrosis may result and lead at a later date to operative treatment because of a painful shoulder.

This review of an important group of shoulder injuries illustrates the careful observation and sound conclusions of Mr. Watson Jones.—*C. L. Scudder, M.D., Boston, Massachusetts.*

DERANGEMENTS OF THE SEMILUNAR CARTILAGES OF THE KNEE. A CLINICAL AND EXPERIMENTAL STUDY. A. R. Shands, Jr., Jay L. Hutchison, and Louis Ziv. *Southern Medical Journal*, XXIX, 1045, Nov. 1936.

This is a study of forty-eight cases with experimental data on the regenerative changes after removal of semilunar cartilages in eleven dogs. Etiology, diagnosis, and treatment are discussed. Patients with acute cases are treated first with physiotherapy. As the patient becomes ambulatory on crutches, the knee is protected by a cotton-board splint and elastic bandage dressing. If the patient is an athlete, a knee-cage brace, made of leather and steel, with joint motion is applied before he returns to active games. If slipping of the cartilage persists, operative removal is advised. Symptoms, operative findings, and postoperative results are charted. Experimental data on dogs showed that there was a definite regeneration after removal of the cartilages.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

ACUTE OSTEOMYELITIS IN CHILDHOOD. DIAGNOSIS AND TREATMENT. H. Earle Conwell and John D. Sherrill. *Southern Medical Journal*, XXX, 171, Feb. 1937.

Emphasis is laid upon the early diagnosis and treatment of this condition. The authors divide the cases into two groups—infants under two years and older children—as

the course of the disease is different. Early and adequate drainage is advocated. Very sick and dehydrated patients are the only cases in which delay is justifiable.

Incision is made over the area of exquisite tenderness. The periosteum is always incised, and holes are drilled into the medulla. When pus is encountered, a window is made into the medullary cavity, as drill holes will fill up with granulations and drainage will be inadequate. Drainage is by rubber tubes and gauze packs. All bleeding points are thoroughly ligated. Transfusions are valuable. Deep x-ray therapy has been used in convalescent cases in which a large granulating area is slow in healing. This hastens the healing. In no cases, however, should the deep therapy be expected to be of benefit to the bone infection.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

THE BONE CHANGES IN SICKLE CELL ANEMIA. L. W. Diggs, E. N. Pulliam, and J. C. King. *Southern Medical Journal*, XXX, 249, March 1937.

This paper summarizes the known facts concerning the pathology and the roentgenographic appearance of bones in sickle-cell anaemia. It is well illustrated and gives charts showing the location of the bone changes in the different bones. The skull picture is very marked and characteristic. The bone marrow is primarily involved. Both osteoporosis and sclerosis are noted.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

AN ARTHROPLASTIC OPERATION FOR CONGENITAL DISLOCATION OF THE HIP—A TWO STAGE PROCEDURE. Paul C. Colonna. *Surgery, Gynecology and Obstetrics*, LXIII, 777, Dec. 1936.

The writer reports six cases of congenital dislocation of the hip, treated by the method which he described in *The Journal of Bone and Joint Surgery* for January 1932. The pathological anatomy is described and the author stresses the "hour-glass" appearance of the capsule and contractures of the soft tissues as barriers to reduction.

The first stage of the procedure consists of subcutaneous tenotomy of the adductors, followed by traction to bring the femoral head opposite the acetabulum. The second stage is the open surgical reduction in which the elongated portion of the capsule is employed as a membrane about the femoral head, which is placed in a reamed-out acetabulum without tension. Postoperative traction is used in the older cases for two weeks, followed by a plaster spica. Weight-bearing is allowed after three months.

The cases presented are adequate to show the efficacy of the method. The article is well illustrated with line drawings of the operative procedure and serial roentgenograms.—*Richard McGovney, M.D., Santa Barbara, California.*

FRACTURES OF THE OS CALCIS. Melvin S. Henderson. *Surgery, Gynecology and Obstetrics*, LXIII, 782, Dec. 1936.

The writer presents statistics and conclusions based on a series of fifty-four cases seen at The Mayo Clinic. Twenty-two of the cases were fresh fractures and thirty-two were old fractures. There were only two females in the entire group. Function only was considered in tabulation of the results.

Most of the fresh fractures were treated by molding and plaster. The use of the Kirschner wire and the Gillette apparatus was recommended. Of these twenty-two patients, seven had excellent results, returning to work in from three to four months; six had good results, working with some pain; two had only fair results after a year; and one claimed complete disability after two years. The results were not known in six cases.

In two-thirds of the cases of old fractures the cause of the disability was astragalocalcaneal traumatic arthritis. Triple arthrodesis was advised in fourteen cases, but was accepted by only three patients.

The period of disability was definitely longer in industrial compensation cases. Where a job was waiting the disability was shorter. The reader is left with the thought that although the disability is considerable at first it gradually lessens over a period of years.—*Richard McGovney, M.D., Santa Barbara, California.*

CRUCIATE LIGAMENT INJURIES CAUSED BY COMPLETE AND INCOMPLETE DISLOCATIONS. EARLY AND LATE PATHOLOGY, SYMPTOMS, AND A METHOD OF REPAIR. William R. Cubbins, James J. Callahan, and Carlo S. Scuderi. *Surgery, Gynecology and Obstetrics*, LXIV, 218, Feb. 1937.

The writers present in all sixteen cases of cruciate-ligament injuries, ten of which were double. There were nine patients with complete dislocation of the knee joint. Five of the patients seen early obtained good functional knees, following reduction and immobilization for four months. The diagnosis should be made by clinical examination, preferably under anaesthesia, as roentgenograms are not informative enough. In the operated cases no traces of cruciate ligaments were found three months or more after the injury. The menisci were not damaged.

A method of reconstruction of the cruciate ligaments is described. A thirteen-inch lateral incision is made, beginning ten inches above the joint; a strip of fascia lata, one inch wide, is dissected down to the lateral femoral condyle; a similar posterior strip is dissected down to the tibial head. The knee joint is then opened by a medial patellar incision. Holes are now drilled horizontally through the lateral femoral condyle, obliquely downward and inward through the medial femoral condyle, and obliquely upward and inward through the medial tibial head. The posterior fascial strip is carried around the fibular head, upward through the fascia and posterior joint capsule, and drawn through the medial femoral condyle, forming the posterior ligament. The anterior ligament is formed by drawing the anterior strip of fascia through the lateral femoral condyle and down through the medial tibial condyle. Both ends are sutured subperiosteally. A plaster is applied with from 25 to 35 degrees of flexion. One full year is required for complete recovery. There were no stiff joints in the authors' series. Too long a period of immobilization is less to be feared than too short a period. The article is well illustrated.—*Richard McGovney, M.D., Santa Barbara, California.*

ZUR VERLETZUNGSBEHANDLUNG (Some Aspects of Traumatic Surgery). *Wiener klinische Wochenschrift*, L, 55, Jan. 15, 1937.

Prof. Wittek emphasizes the early and proper treatment of lacerations of the knee joint, and presents a method which he employs to promote ankylosis of pseudarthroses following fractures of the femur which have resisted other forms of treatment. It embodies the principle of functional burdening whereby abnormal mobility in the sense of lateral or longitudinal displacement is to be safely avoided. The method consists in drilling two extension wires, one above the femoral condyles and the other in a sagittal direction, through the greater trochanter. These are placed in tension stirrups and the pelvis and the affected thigh with its wires are enveloped by a plaster cast. Further treatment is ambulant. This method also provides early ambulatory treatment for fresh fractures of the femur. Wittek states that he subsequently learned that a similar method was in use in the United States.

In sixty-two cases of knee lacerations (thirty-nine with open joint injuries) reaching the Clinic within forty-eight hours following injury, surgical treatment resulted in fifty-nine complete cures and three stiff joints. Twenty-eight patients, entering later than forty-eight hours after injury, with some inflammatory changes already present, recovered with little loss of knee function. Of thirteen patients previously treated and brought in with severe infections, four died, one required amputation, two became ankylosed, and six recovered with more or less limitation of motion. Of forty-five patients who were sent in for supplementary care, pain and limitation of motion resulted in seventeen; three presented only amputation stumps; eighteen, ankyloses; five, contractures; and two, previously undiagnosed division of the ligamentum patellae.

Such statistics are to be improved only by adherence to the following rigid principles of treatment: (1) immediate excision of all tissue suspected of being infected; (2) primary closure of the joint capsule and reestablishment of joint function; (3) prophylactic filling of the joint with an antiseptic; and (4) immobilization.—*O. Theodore Roberg, Jr., M.D., Chicago, Illinois.*